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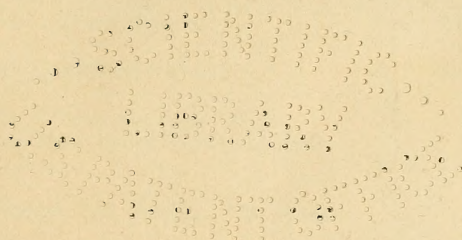
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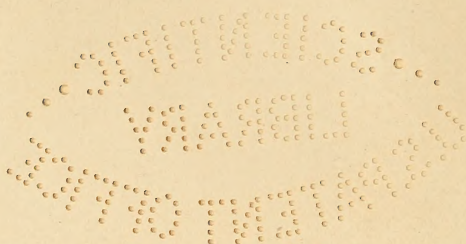
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Edward Daniel Meier was born in St. Louis, Mo., in 1841, and was educated in the local schools of his native city, at the Washington University, St. Louis, and at the Royal Polytechnic School, Hanover, Germany, this being followed by a practical apprenticeship at the Mason Machine Works, Taunton, Mass. At the outbreak of the civil war he enlisted in the Grey Reserves, the Thirty-second Pennsylvania, and served in the Army of the Potomac until after the battle of Gettysburg. He subsequently served in the Second Massachusetts Battery, also in the United States Engineer Corps, and finally became lieutenant in the First Louisiana Cavalry, seeing much active service and receiving the surrender of Lieutenant-General John B. Hood and three members of his staff on May 30, 1865.

After the close of the war he was employed by the Rogers Locomotive Works, by the Kansas Pacific Railroad and by the Illinois Patent Coke Company, and in 1873 was engaged in the construction and operation of blast furnaces at Bessemer, Ill. During 1875-1884 Mr. Meier devoted his energies to the St. Louis cotton industry as engineer, and designed improved and efficient machinery for baling cotton. In 1885 he organized the Heine Safety Boiler Company, for the development in the United States of the water-tube boiler of that name, and has been its president and chief engineer ever since. He has been secretary, and is now president, of the American Boiler Manufacturers' Association, and has done much to secure the preparation and adoption of standard specifications for boiler material and construction. He also introduced the Diesel motor into the United States, and is the consulting engineer of the Diesel Engine Company. Colonel Meier was Colonel of the First Regiment of the Missouri National Guard for about ten years, and is a member of the Grand Army of the Republic and of the Loyal Legion. He is a past president of the Engineers' Club of St. Louis, and has been especially active and devoted to the American Society of Mechanical Engineers, having served on many committees, including four years on the important finance committee, of which he was chairman for two years. He has twice been elected vice-president, being senior vice-president at the present time.



COL. EDWARD DANIEL MEIER,
SENIOR VICE-PRESIDENT AMERICAN SOCIETY OF MECHANICAL ENGINEERS

See Reverse Side.

CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

VOL. XXXIX

NOVEMBER, 1910

No. 1

ENGLISH NAVVIES AND AMERICAN STEAM SHOVELS

By A. F. Dickinson, B. Sc.

SINCE the introduction of the first steam excavator early in the last century, mechanical excavating appliances have played a very important part in the history of engineering.

The increasing cost of modern labour would, without their aid, have rendered impracticable, owing to excessive cost, very many of the important undertakings of late years.

The best known of all mechanical excavators is the steam navvy, or, as it is known in the United States, the steam shovel, which has come into general use from its economy and general convenience under a variety of conditions.

In England these machines have been mainly developed by Messrs. Ruston, Proctor & Co., and their manufacture is still confined to a few firms. There has been a steady and continuous improvement in details since their introduction.

In the United States, on the other hand, there are a number of firms who devote themselves to this class of machinery, but, while their products differ in detail, the development of the steam shovel has been along the same general lines throughout the United States, though differing considerably from the English type.

It may be of interest, therefore, to

compare the typical American steam shovel with what we may regard as the typical English navvy, and in this way to bring out the most striking features of the two types.

The influence of the Panama Canal on the development of the American excavator has been very great. Since the recommencement of the work the sizes of excavators employed have greatly increased, as has also the efficiency of the machines, and more especially of the methods of working them.

Some idea of the importance of efficient working may be gained from the numbers employed.

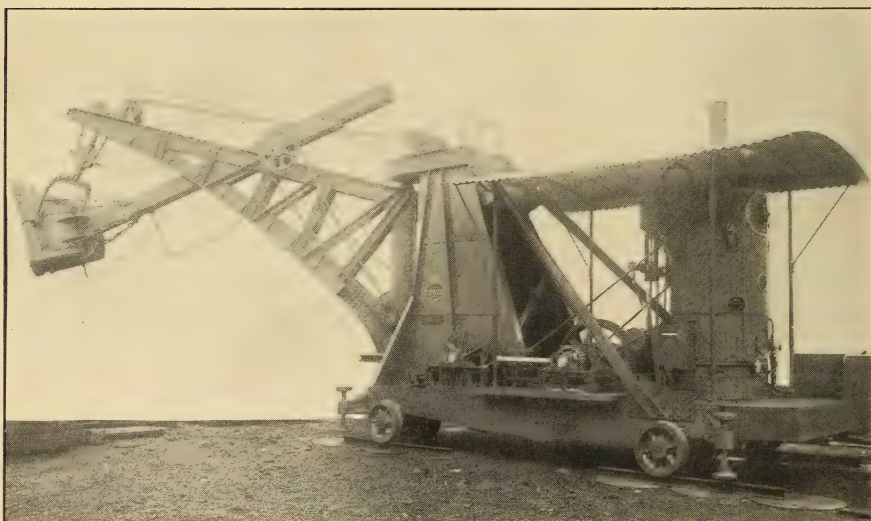
On this work there were (last year) fifteen 105-ton machines of the Marion type, thirty-two 95-ton Bucyrus and many smaller excavators, the total number employed reaching 100. Up to the present the 105-ton shovels hold the record in size. They have a bucket of 5 cubic yards capacity, a length of body of 42 feet and a capacity of 2,000-5,000 cubic yards per ten-hour day, according to the nature of the ground in which they are working. One of these shovels is shown at work in the Culebra Cut, Panama, where on one occasion it is reported in the Canal Record to have loaded 313 10-cubic yard cars in 370 minutes. The 95-ton Bucyr-



THREE 100-TON MARION STEAM SHOVELS WORKING ON DIFFERENT LEVELS OF THE PANAMA CANAL

rus shovel has to its credit the substantial record of 3,941 cubic yards in 8 hours, and of 58,483 cubic yards in 27 8-hour working days.

As compared with these the heaviest Ruston & Proctor type navy weighs only $36\frac{1}{4}$ tons with a 2-yard bucket and stated output of 800 to



THE RUSTON NO. 10 STEAM NAVY. RUSTON, PROCTOR & CO., LTD., LINCOLN



A 95-TON BUCYRUS SHOVEL AT WORK IN THE CULEBRA CUT. THE RECORD HOLDER ON THE PANAMA CANAL

1,000 cubic yards per day in good soil.

The two types can be compared by examining the illustrations, which show the striking differences between them.

One of the most characteristic fea-

tures of the Ruston & Proctor navy is the "tower," which is replaced in the American machines by a tripod of steel legs with cast steel yoke-piece.

The comparatively great length of the American type will also be noted.

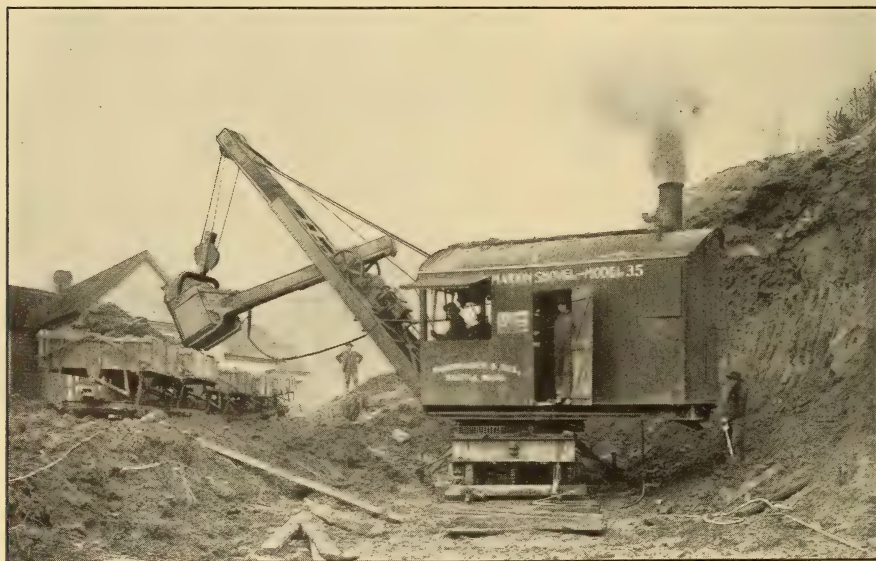


LIGHT STEAM SHOVEL WORKING IN A BRICKFIELD AND DEALING WITH SUFFICIENT CLAY TO MAKE 40,000 BRICKS PER DAY. RUSTON, PROCTOR & CO., LTD., LINCOLN

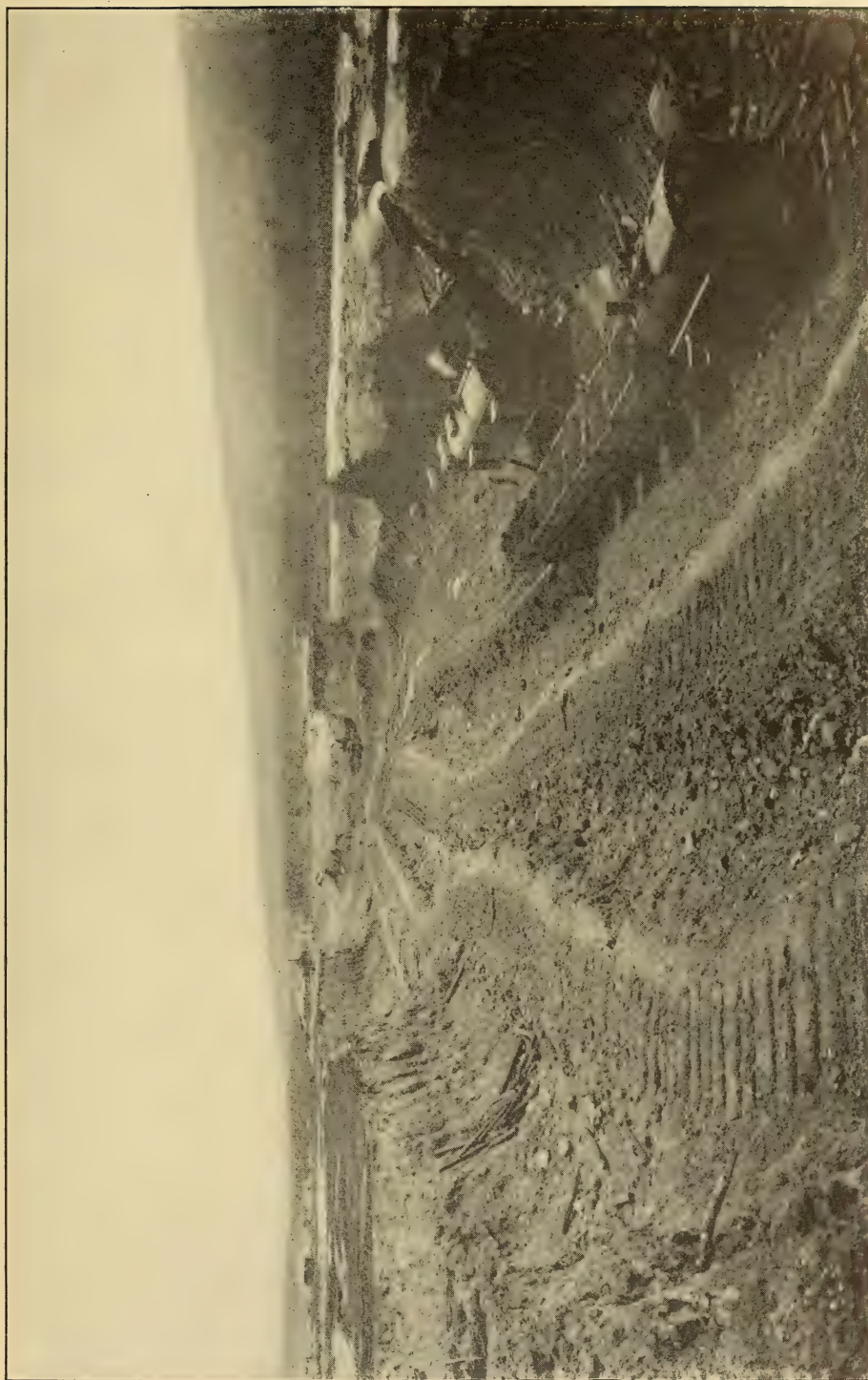
It is the general practice in all the larger sizes to carry the machine in bogies instead of two single axles. This method distributes the weight over a larger area and increases the mobility, for with the bucket unshipped the American machines can be run without difficulty over the railway track as an ordinary car, for which purpose they are equipped

with the Westinghouse brake. The great length of wheel base also gives stability when digging. Lateral stability is similarly secured by jacks, which are fixed on swinging frames to increase the speed.

These frames can be folded against the side when out of use or when standing at right angles to the frame project about five feet outside it. In



MARION REVOLVING SHOVEL AT WORK ON STREET GRADING IN SEATTLE. MARION STEAM SHOVEL COMPANY, MARION, OHIO



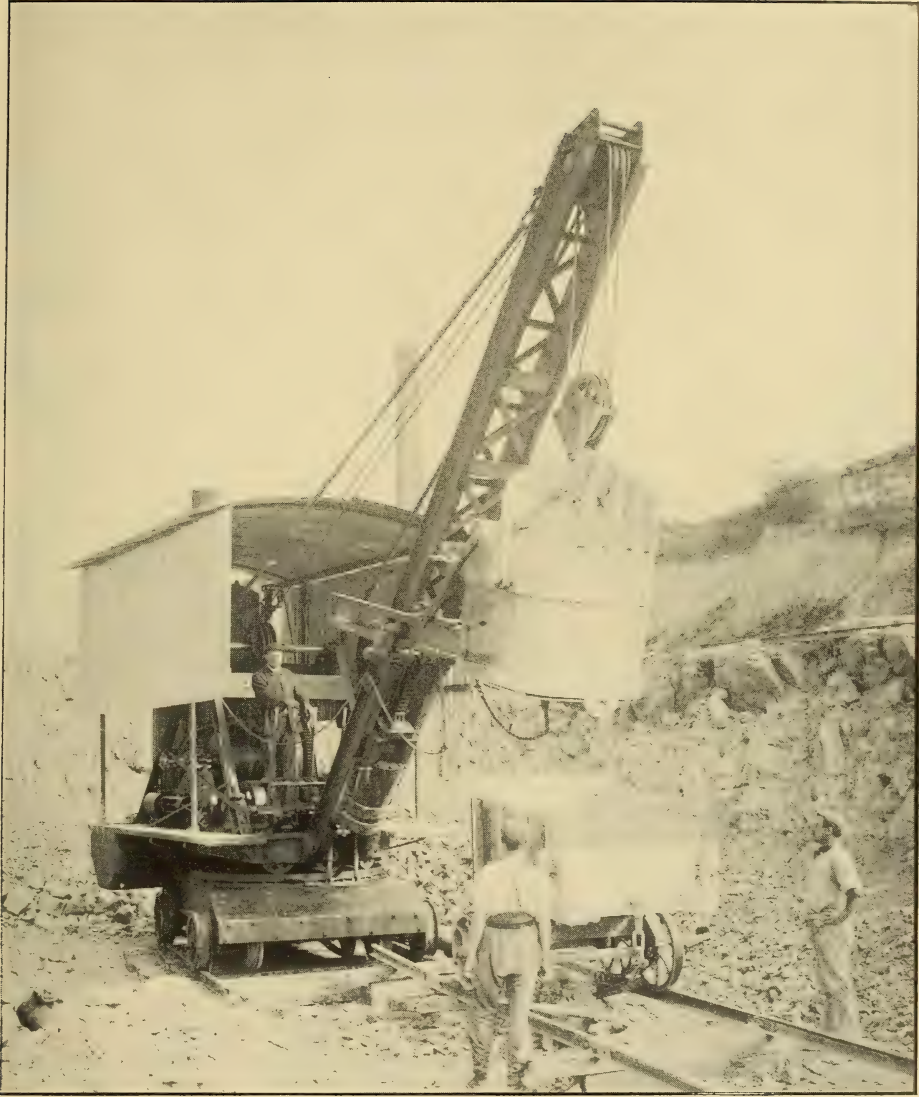
COAL STRIPPING WITH BUCYRUS SHOVELS, NEAR HAZETON, PA. THE BUCYRUS COMPANY, SOUTH MILWAUKEE, WISCONSIN.



A RUSTON 12-TON CRANE NAVY EXCAVATING LIMESTONE WITHOUT THE ASSISTANCE OF EXPLOSIVES



BUCYRUS STEAM SHOVEL HANDLING ROCK ON THE NEW YORK STATE BARGE CANAL NEAR LOCKPORT



A RUSTON CRANE NAVY WORKING IN A NARROW CUTTING AND LOADING WAGONS IN THE REAR

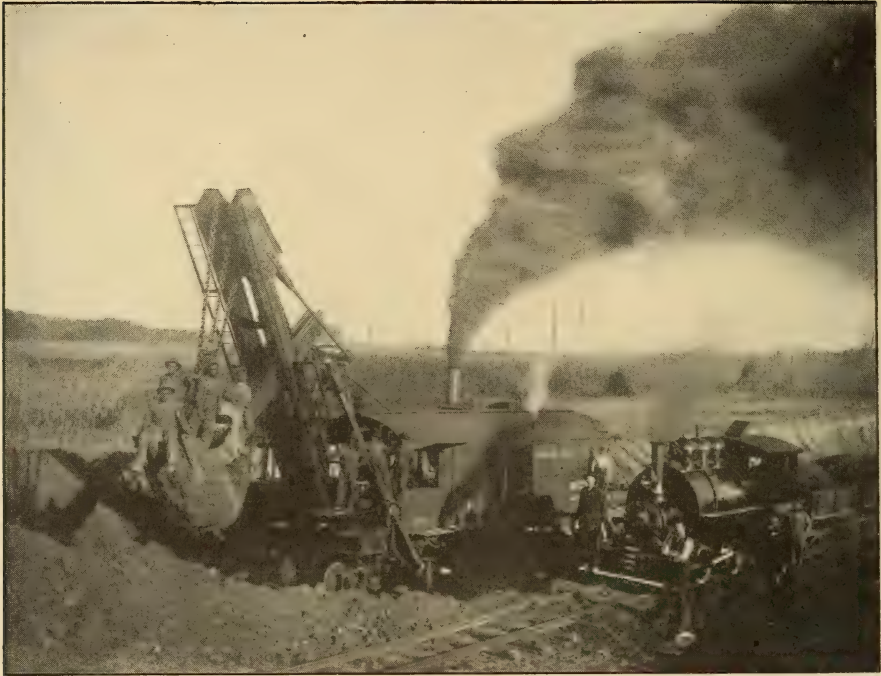
this manner a spread of as much as 20 feet can be obtained and the weight spread over a large area by timbers. Long brace-rods stretch from the rear of the body to the jack frames to hold them in position when extended.

As a result of this the stability obtained allows the use of long bucket arms—that of the 105-ton machine is ordinarily 30 feet and in some ma-

chines are made longer, and in fact necessitates them, as the wagons have to run up outside the jack frames and thus require extra width of gullet.

On the other hand the Ruston & Proctor machine is supported on 5 jacks close to the frames, so that the width of gullet is not necessarily so great with this type.

Either as a cause or result of the



A BUCYRUS SHOVEL AT WORK ON THE BURLINGTON RAILROAD IN SOUTHERN ILLINOIS

great body length of American machines the locomotive type of boiler is generally used, though it is very exceptional in England, where, with the exception of the Wilson "12-ton" navvy, all machines are fitted with vertical boilers.

Another radical difference in the two types is in the arrangement of the engines. The usual practice in America is to divide the engines into three or four independent sets, each controlling one motion.

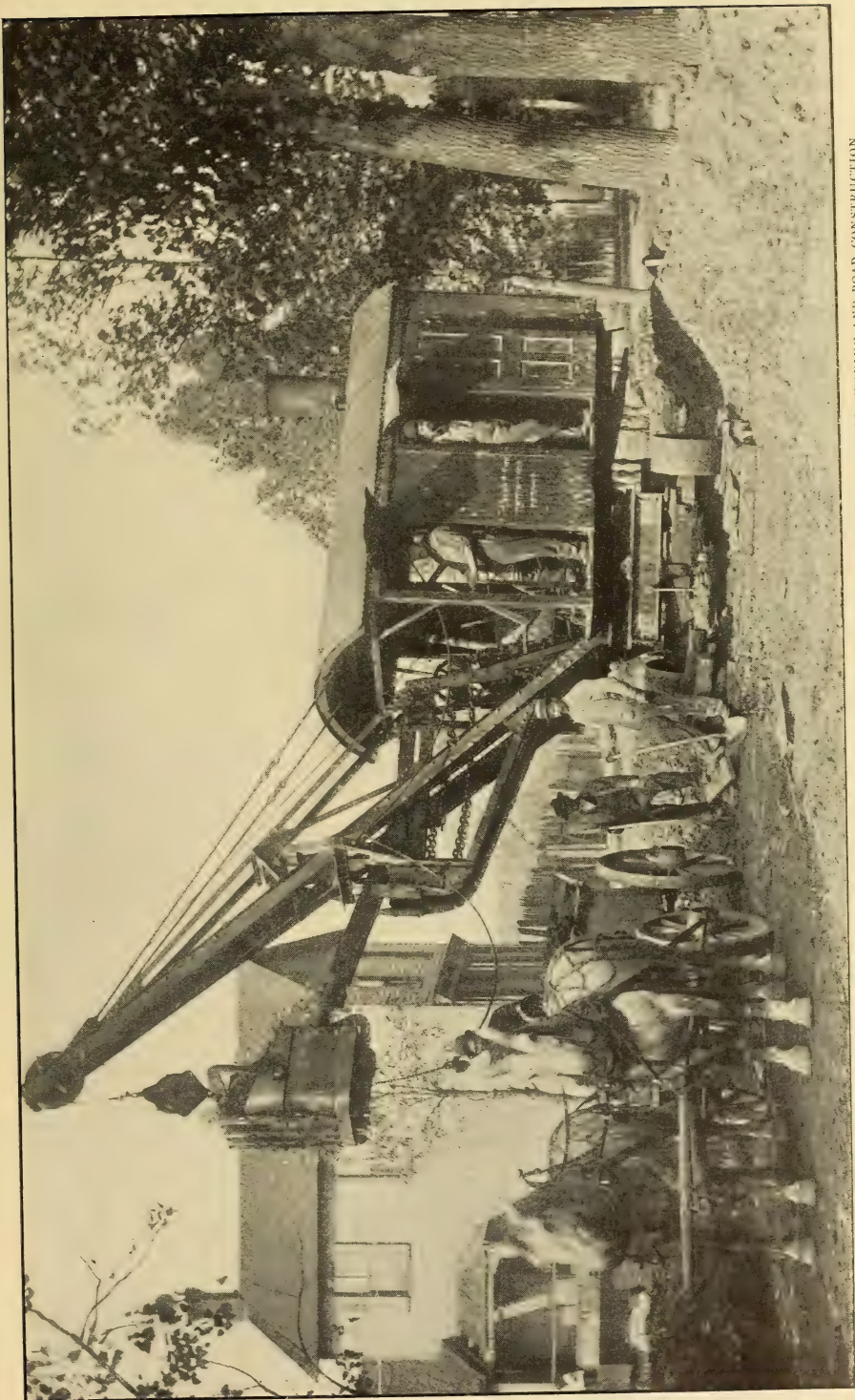
This simplifies the gearing and dispenses with the need of a friction drive, which is necessary with single engines in case of any motion being "brought up" in order to prevent breakage.

The hoisting engines are generally placed about the middle of the body and are sometimes also used to drive the propelling gear.

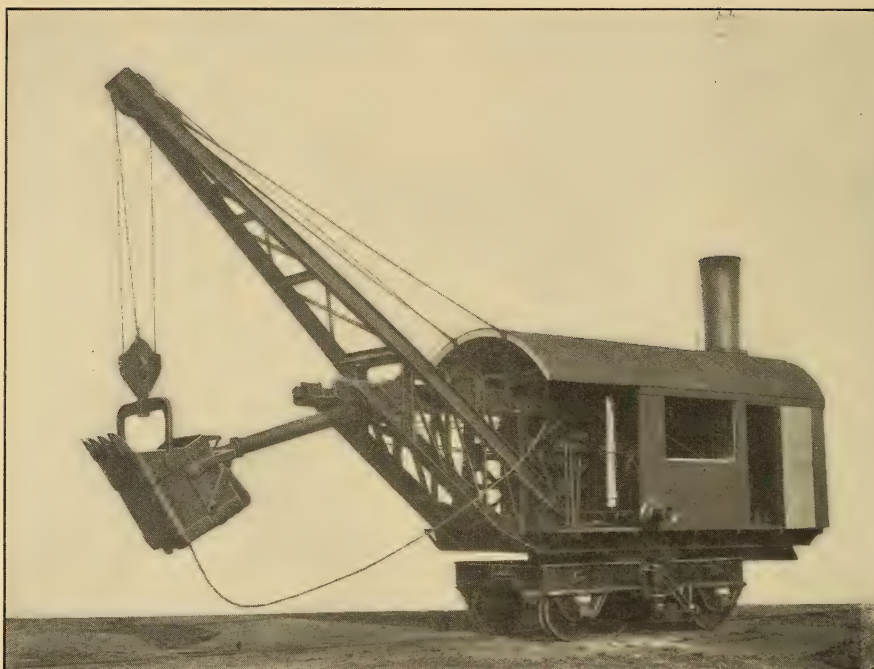
The swinging engines control the jib by means of chains working round a vertical drum and are placed on the body behind the hoisting

gear. The "racking" or "crowding" engines are nearly half-way up the jib and receive steam through a pipe with universal joints.

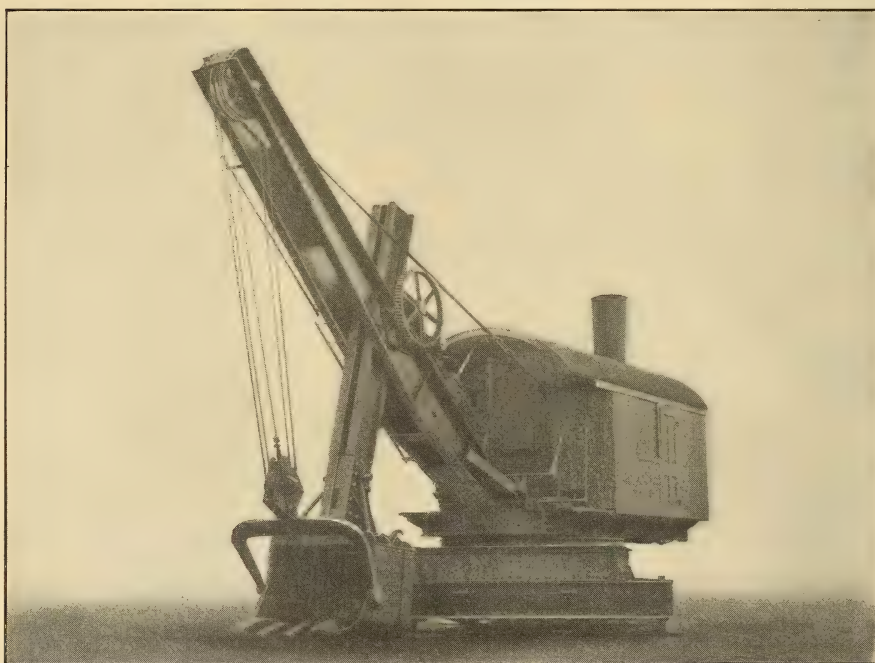
The Ruston navvies are driven from one set of engines bolted vertically against the boiler. In some English types, however, the racking or crowding is worked independently, notably in the Wilson and Whittaker machines, in which the bucket arm is controlled by a simple piston and long cylinder. This arrangement, though simple, necessitates a very long cylinder to obtain great reach, and is used as a rule only for crane type navvies, as described later. An unusual method is employed in the Thew Automatic Shovel to obtain this motion, by means of which feed is given entirely in a horizontal direction. This has great advantages in obtaining perfect level and allows great reach. The principle will be seen in the illustration, from which it will be seen the bucket arm is carried in a carriage or trolley moving



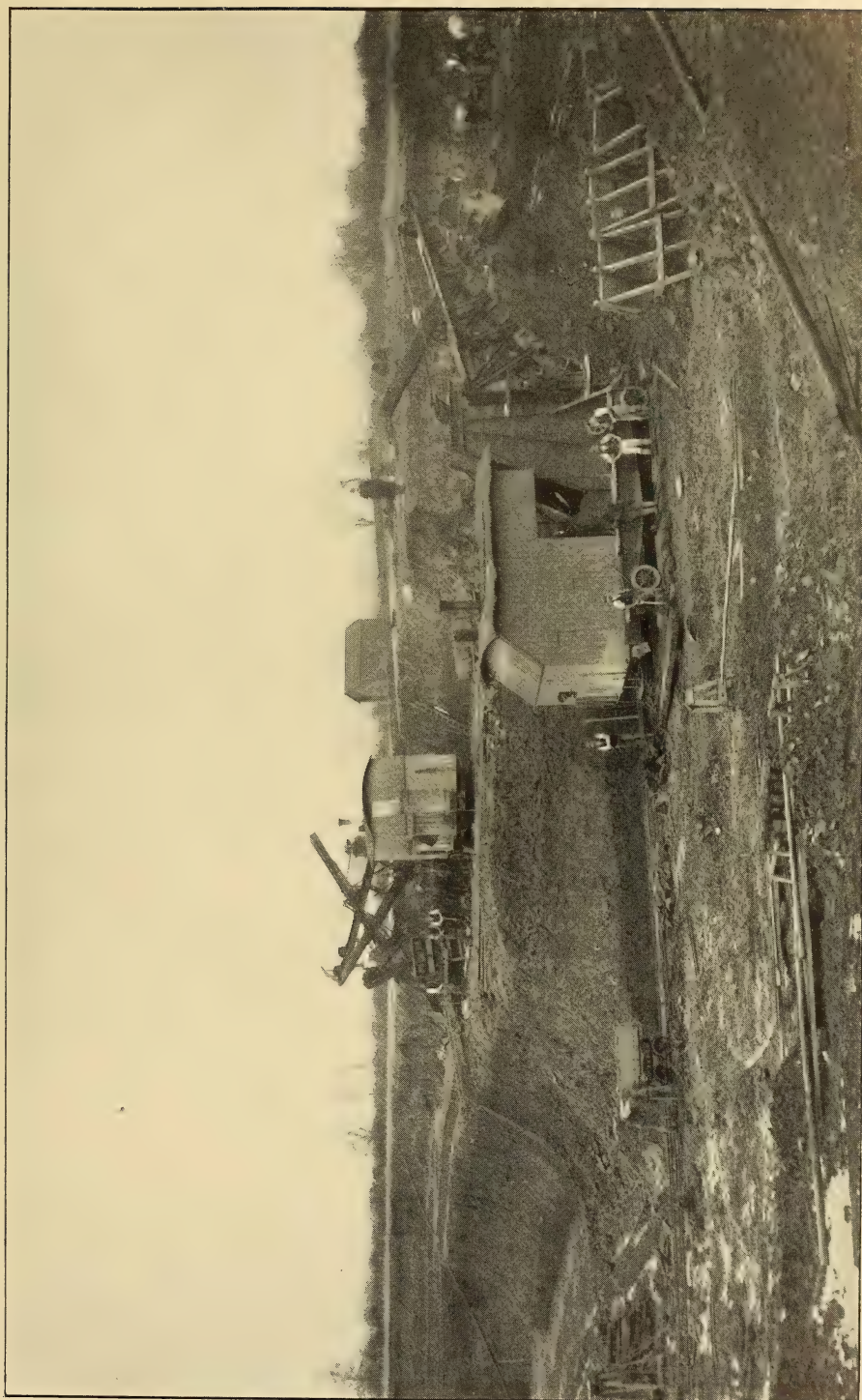
THEW FULL CIRCLE STEAM SHOVEL WITH HORIZONTAL DIPPER CROWDING MOTION AS APPLIED TO STREET GRADING AND ROAD CONSTRUCTION



FULL CIRCLE SHOVEL FOR GENERAL CONTRACTING WORK. THE AUTOMATIC SHOVEL CO., LORAIN, OHIO



FULL CIRCLE SWING SHOVEL WITH JACK SHAFT BOOM. THEW AUTOMATIC SHOVEL CO., LORAIN, OHIO



RUSTON NAVVIES IN A BRICKFIELD. THE UPPER ONE STRIPPING THE OVERRURDEN AND THE LOWER ONE EXCAVATING THE CLAY. RUSTON, PROCTOR & CO., LTD., LINCOLN



JUBILEE TYPE EXCAVATOR WITH INSIDE AND OUTSIDE AXLE WHEELS FOR EXTRA RAIL SUPPORT, AND SPECIAL STEAM CYLINDER ON BUCKET ARM. JOHN H. WILSON & CO., LTD., BIRKENHEAD

along on girders. This form is especially useful on shallow cuts.

The buckets used vary in size and shape according to the nature of the ground. In very hard ground or where boulders are met with, the bucket is often made shallower to minimize the effect of the blows caused by dropping pieces of rock on the bottom door.

Hard rock can be taken if loosened by blasting, and some idea of the bad ground that can be excavated may be obtained from page 8, which shows a 70-ton Bucyrus at work. In the background is a conveyor on to which it is loading.

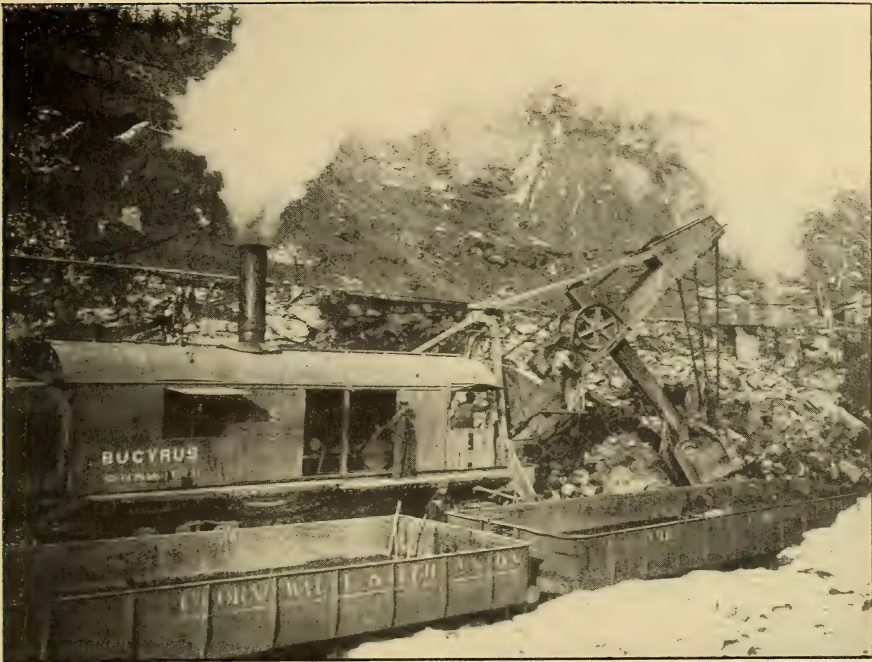
In the lighter classes of excavators modifications are made to increase mobility and ease of working. The heavier machines described have a swing not much greater than 180 degrees, necessitating side emptying and therefore a wide gullet.

The full circle or crane type is well known and needs no special description.

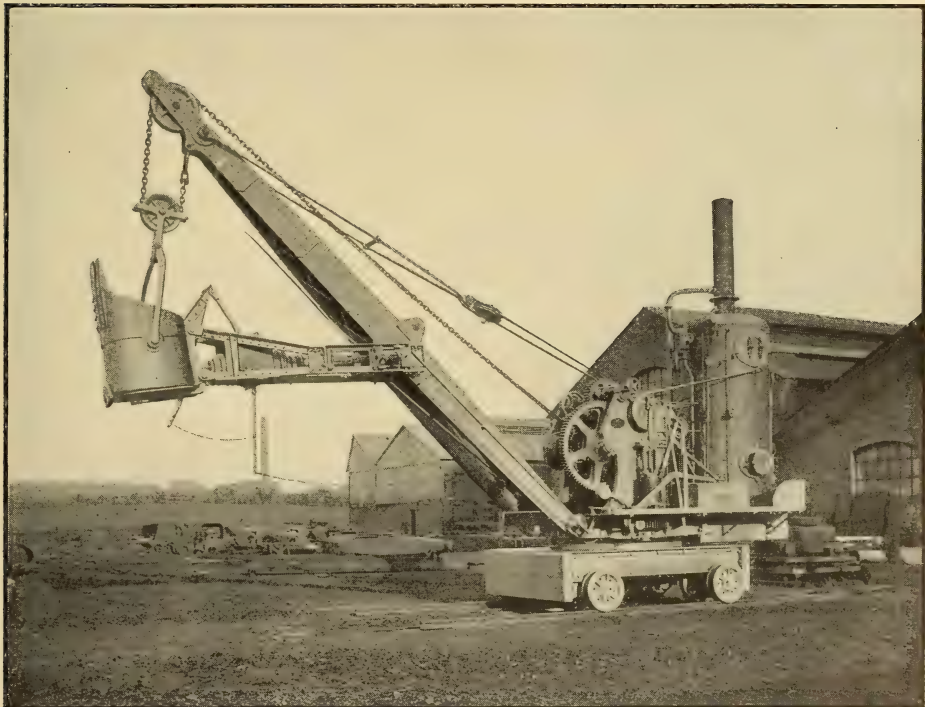
In the above illustration is shown a large example of the English type. It is by Messrs. Wilson, of Birkenhead, and weighs 43 tons, being convertible by removal of the bucket into a 12-ton crane. It will be noticed that the boiler is of the horizontal type, which is unusual in English practice. Another modification recently introduced into England, but considerably developed in the United States, is the navy mounted on traction wheels in place of flanged wheels, thus avoiding the use of rails and sleepers.

A light machine by Messrs. Ruston & Proctor, weighing 17 tons, is shown in the illustrations, but in the United States shovels up to 70 tons weight have been so mounted.

Propulsion is by chains to the



A BUCYRUS SHOVEL STRIPPING ROCK FOR ANTHRACITE COAL MINING. CORNWALL ORE BANK CO., PENNSYLVANIA



STEAM CRANE EXCAVATOR; 8-TON CAPACITY. JOHN H. WILSON & CO., LTD., BIRKENHEAD



MARION SHOVEL WORKING ON THE LIVINGSTON CHANNEL IN THE DETROIT RIVER. THE LARGEST SHOVEL EVER MOUNTED ON TRACTION WHEELS



MARION STEAM SHOVEL MOUNTED ON TRACTION WHEELS AND GRADING STREETS IN SEATTLE.
MARION STEAM SHOVEL CO., MARION, OHIO

front wheels and steering is effected by a separate engine through the rear wheels, the axle of which is able to swivel. The machine can thus be driven at about 2 miles per hour. The advantages of traction wheels when the ground is sufficiently firm are obvious and their use will probably increase considerably within the next few years.

Though all the above described machines are generally worked by steam power, electrical driving is coming into favour and, where power is available at a cheap rate, is economical and efficient. When electrically driven the only change involved is the replacement of boiler and engines by motor, all the gearing remaining the same. Some saving in weight is obtained as well as greater convenience in working.

Hydraulic working has been tried at the Alexandra Dock at Hull. A saving in weight was effected, but the expense of laying down a hydraulic system must prevent this being widely used.

Compressed air as a motive power is useful for tunnel work, the most usual method employed being to use the ordinary steam boiler and engines and merely force air into the boiler.

The tendency of late years has been to increase the size of these excavators, especially in America, and we have to consider the various advantages and disadvantages attending this increase. There can be no doubt that, when very great masses have to be excavated, as at Panama, these very large machines are economical, provided that the ground is of sufficient firmness to withstand their weight. Even then, though they work with great rapidity, the expenses of laying roads and feeding them with wagons increase very rapidly after a certain point, and the use of the very large shovels involves enormous outlay on plant.

Four or five-yard buckets necessarily involve the use of wagons of 10 to 20 yards capacity for efficient



THE LIDGERWOOD RAPID UNLOADER AT WORK

feeding, and these in turn necessitate the continuous attendance of a locomotive and arrangements altogether on a much more elaborate scale than those required for smaller navvies and 3 to 5-yard wagons, as seen in England. The difficulties of economically feeding large excavators were severely felt at Panama, where the most up-to-date plant was available until the organization had been improved after several years of experience and trial—and this was before the very largest machines had been introduced. Temporary roads

for these heavy wagons involve great expense and care, as any upsets or derailments become serious matters with 10 to 20-yard wagons and may delay the whole working for some time, while there is additional difficulty in tipping.

In bad ground and where much water is met with, all these difficulties are increased, as well as the trouble of working the navvy itself. Anyone with experience of a 36-ton machine in a wet dock bottom in winter can imagine a 105-ton shovel in similar circumstances. To overcome the difficulty in tipping and to secure increased stability in the wagons, the ordinary tip wagon is now often replaced with flat wagons and patent unloaders, and this system was introduced at Panama. These wagons were of 10 yards' capacity and fitted with hinged flaps on the sides and also at the ends. When these latter were lowered the train formed one continuous platform. Along this the unloader or plough was drawn by a wire rope, usually worked from a drum on the locomotive,

but sometimes from a special car next to it.

The illustration shows a Lidgerwood rapid unloader at work. Ploughs can be made to unload at either or both sides together, and by moving the engine backward or forward while the plough is being drawn forward, the material can be unloaded all at one spot or spread out evenly over a long length of tracks.

With the extension of these and other methods of conveying and handling the excavated material, a general increase in efficiency of machinery, there can be no doubt that the economical limit of size for excavating machines will continue to rise, especially if stimulated by further undertakings of the magnitude of the Panama Canal.

Possibly, should the much-talked-of Clyde to Forth Canal at Rosyth be carried out, the next step will be taken in Great Britain.

The writer is indebted to the courtesy of the makers for information and leave to publish the illustrations.

INSURANCE SURVEYING AND MAP MAKING

By R. P. Getty

MANY persons must have noticed, when making application for fire insurance, that it is the practice of the underwriter to examine certain maps before he will fix the rate of premium, or accept a risk on the property offered. His lithographic surveys marked off in diagrams of red and yellow and other colors are always in evidence, sometimes bound securely in dozens of large volumes, on other occasions laid conveniently in piles of loose sheets for handy reference.

Few persons realize, however, that these maps contain all the information which the underwriter desires to know about the building he is asked to insure, and that in most instances more matters are explained to him by a single glance than the applicant could make, even though he be the owner of the property.

As a matter of fact the details set forth are most explicit. The map maker has managed by colors, characters and signs to give a full description of the construction, equipment and occupation of the building, everything which over fifty years of this sort of surveying has proved to be of any possible interest to the insurance man. It is so complete, for instance, that an agent in New York City can readily form a good idea of the character of a risk situated in some town in Missouri or California, or, *vice versa*, agents in towns in these western States can likewise tell the character of a risk in New York City.

The origin of insurance surveying and map making is shrouded in some uncertainty. Probably the system started in the City of London

in 1785, when certain insurance companies endeavored to devise a scheme whereby their risks could be so apportioned as to prevent the failure of a company in the case of a disastrous conflagration. About this time Mr. Thomas Leverton, who was connected with the Phoenix Fire Insurance Company of London, prepared a plan of the central part of the city, and in it colored each district in such a way that he could tell immediately the character of every building in the territory that had been mapped out.

The beginning of the system in New York City was largely due to the energy and foresight of Mr. George T. Hope, the secretary of the Jefferson Fire Insurance Company. Previous to 1850 no method was in force by which the amount of insurance being carried in the proximity of an applicant's building could be quickly determined, and for this reason the companies sometimes found themselves burdened with risks that had been overlooked in a hasty examination of the pages of their record. Such a case had happened at the corner of William and Cedar Streets, then near the heart of the drygoods district, when the store occupied by Davison & Van Pelt was destroyed by fire and several other buildings in surrounding streets received serious damage.

Certain insurance companies, the Phoenix among the number, sustained large losses in this catastrophe, and Mr. Hope resolved that such a thing should not happen again if he could help it. Accordingly, he began the preparation of a large map of the business section of New York

City for his own use. Before the surveys were finally completed for this map Mr. Hope's plans were changed. Mr. William Perris, an English engineer residing in New York City, offered to extend the idea, and prepare a map that should contain every building in the city. Mr. Hope approved the plan and appointed a committee to supervise the work, of which he was chairman, the other members being Messrs. Charles J. Martin, Daniel Underhill, James H. McLean and J. Milton Smith. These gentlemen decided that this map should show the nature of the different materials used in the construction of all buildings by a system of colors which they named, and they also designated a few simple signs for other purposes. The Perris map was completed and proved a success from the start, thus establishing a new industry and one that was destined to become a necessary adjunct of the fire insurance business.

Mr. D. A. Sanborn was the first man to formulate insurance map-making on a large scale. This gentleman had been a civil engineer at Somerville, Mass., and moved to Cincinnati in 1865 to make surveys for the Ætna Fire Insurance Company. Mr. Sanborn shrewdly reasoned that if his surveys were valuable to the Ætna Fire Insurance Company they should be useful also to fire insurance companies generally. So in 1866 he went to New York, and started the D. A. Sanborn National Insurance Bureau. The scheme appealed immediately to the insurance companies, and before the year was ended Mr. Sanborn had enlisted in his enterprise such men as Mr. Hope, who had been promoted to the presidency of the Continental Fire Insurance Company, Mr. George L. Chase, the president of the Hartford Fire Insurance Company, Mr. Feter Notman, the president of the Niagara Fire Insurance Company and several other prominent underwriters. The business of insurance

surveying and map making increased forthwith, and Mr. Sanborn's bureau was kept busy furnishing diagrams of buildings, which were situated in towns all over the country. These surveys at first only covered the thickly populated portions of the larger towns and cities, and when a company required a diagram of property that was not on the list, it was often necessary to wait several weeks before the one wanted could be furnished. Gradually, however, the surveys were extended with the object in view of eventually taking in every part of a city or town in the United States.

In December, 1875, Mr. Sanborn formed the corporation known as the Sanborn Map Publishing Company, Ltd., and established an extensive plant for insurance surveying and map making in the City of New York. He died in 1883, and in 1889 his successors incorporated with the firm of Perris & Browne of New York City, themselves the successors of the William Perris, who made the first map for insurance purposes. Mr. Charles B. Brush of Hoboken and Jersey City, and the Rascher Map Company of Chicago, later joined them. This corporation was known as the Sanborn Perris Map Company. The present Sanborn Map Company maintains a series of maps that comprise every city and town in the United States, the total number controlled by it running up into tens of thousands. The company has agencies at Great Britain, Canada, France, and at Hoboken, Chicago, San Francisco, St. Louis and other cities in the United States.

In making insurance maps certain features were considered essential, and the growth of the system has proved their wisdom and changed them only as regards the amount of detail that has been incorporated. Of first importance were the colors to show the different materials used in the construction of a building. Naturally red seemed a proper color to

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signify brick and yellow to signify wood. These colors have always been employed for these materials. Other colors have been added from time to time, thus blue for stone, grey for iron, etc.

In fixing signs and character for such details as stairways, fire escapes, dumbwaiter shafts, etc., a principal object was to make them plain and distinct. They must be easily understood by an underwriter without reference to any key or marginal foot notes.

This object has been carried out, with the result that when these insurance maps are examined by an insurance man to-day each sign or character has such an individuality of its own that it can be easily distinguished and is not confused with another.

An important feature was to prepare the maps in such a manner that they could be revised and corrected without much labour or the large expense of new maps. To meet these requirements two kinds of maps have been adopted and are in general use at the present time, known technically as bound maps and sheet maps. In the larger cities the buildings erected are generally substantial and can be relied on to remain practically intact for a number of years at least. There are records of surveys of such buildings being available with few corrections for a period of fifteen years. Accordingly, all the separate sheets of surveys in large cities are bound together like an atlas when completed and are corrected, when necessary, by pasters which contain a diagram of the new or remodeled building. These pasters are furnished periodically to the map subscribers and can be easily glued over an obsolete diagram.

In the smaller cities and towns, especially in those which show rapid increase in building operations, such a plan would not suffice at all. The maps of these places, therefore, are made on sheets 21 by 25 inches in

size, in varying scales, and are kept unbound so that new and corrected sheets can be substituted for the antiquated ones at short notice. A key map is used in conjunction with these insurance maps that not only shows the immediate territory mapped out but the surrounding country. The street and block numbers are designated on these key maps as well as on the detail maps. It is usual, also, to mark in the stations of every fire hydrant and fire house and to note in a column by themselves the special hazards or risks about the town mapped out.

Corresponding to each detail map in the bound map of large cities and set opposite it in the binding is a skeleton map, which is a replica of the detail sheet so far as the outline of each street and building on that special sheet is concerned. On this skeleton map the underwriter is supposed to write a memorandum of his risks. These skeleton maps are never corrected and never used in the smaller cities or towns. The amount of detail that is given on a modern insurance map will doubtless be astonishing to the reader. Take a city like Cohoes in New York State for example, a thriving town of twenty-four thousand inhabitants. An underwriter is asked to insure a certain building at Cohoes. He turns to the key map and obtains there the street and block number. Then, turning to the street indicated and the proper block, he can tell immediately the exact size and shape of the building in question. He is shown by the coloring of the diagram the kind of material used in its construction. If it is a fireproof building, the color will also determine that fact. The height of the building is given, not only in the number of the stories, but in feet. He can tell whether it contains a cellar, or subcellar, the thickness of the walls at each floor, the style of roof and whether the latter is constructed of metal, slate or composition. Suppose the underwriter should

wish to know something about the windows. The windows at the rear wall are indicated, and if the building is detached from others, those on each of the side walls. When there are iron doors and iron shutters these are indicated, and also the skylights on the roof and whether protected by wire glass or by screens. If there are fire walls, the height of them is shown and whether the cornice is of frame or metal construction. The underwriter can also tell by these maps the position of the interior arrangements of a building, like stairways, dumbwaiter shafts, elevators, etc. There are even included such obscure things as bake ovens, furnaces, coal chutes, forges, kitchens, etc.

The occupancies of all buildings are considered important and are clearly designated. Thus, an underwriter can distinguish a dwelling from a flat or ordinary tenement. Apartment houses are generally designated by their names. Distinctions are also made of trades or occupations that are considered hazardous, as blacksmith shops, book binderies, paint shops, carpenter shops; and they are all specially noted.

But this description of a building in question, full as it may seem, does not end all the information imparted to the underwriter. These insurance maps also contain a general report of the town they cover and give the size of its population, the prevailing direction of its wind, the grade, manner of construction and general condition of the streets and the character of the public lighting system. Under the head of fire department is stated the sort of apparatus in use, the length of the hose, its condition, the number of fire companies. If there is a paid fire department the number of firemen is noted; if it is a volunteer department the number of fire companies and the membership. When the town contains an electric system, the name of the system and the number of alarm boxes

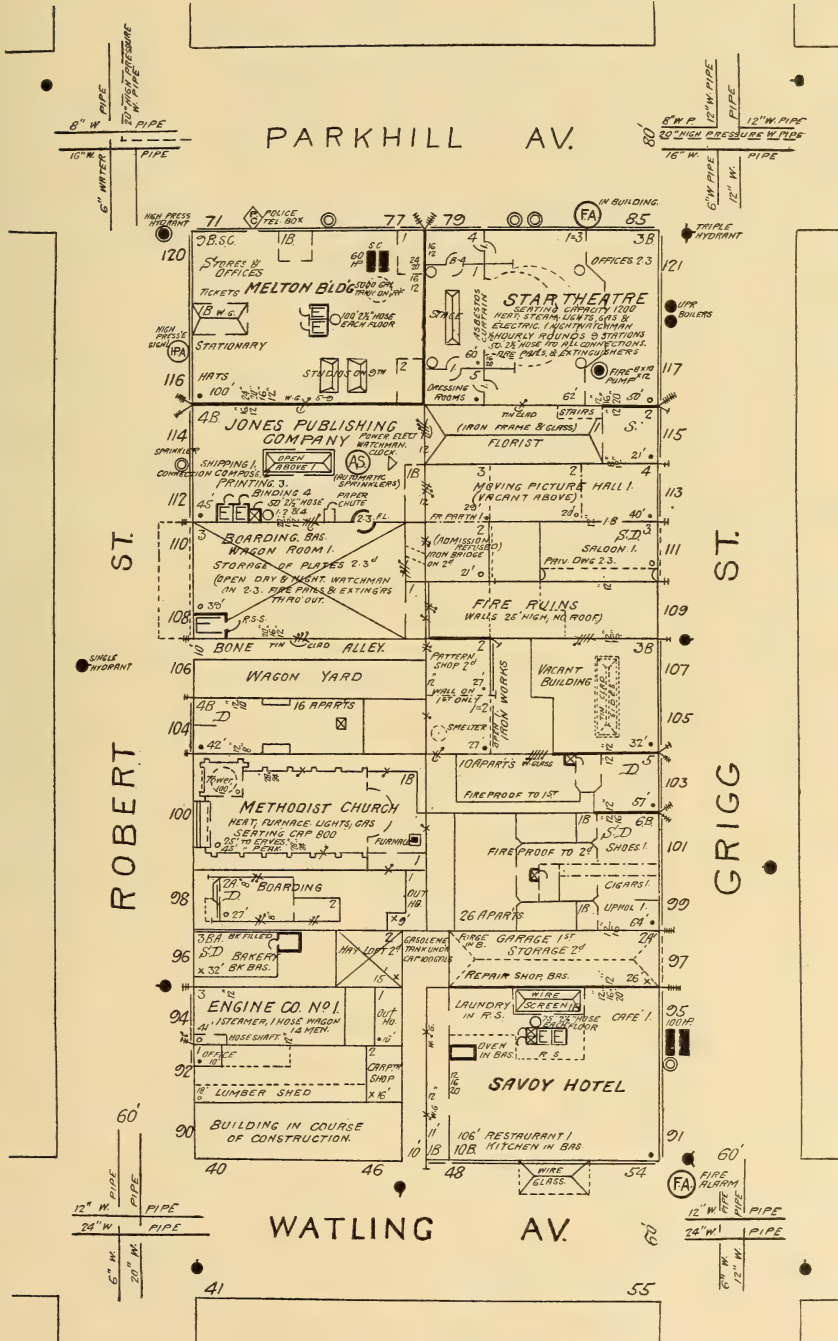
are given. Under the head of water works this branch of a town's service is succinctly explained. There is told the source of supply, the makes, sizes and capacities of the various pumps, the daily consumption of water, the pressure for domestic and fire use, the number of hydrants and the sizes and the number of miles of water pipes. If there is a water tower, the elevation of the base above the business portion of the town is given and its storage capacity in the number of gallons.

Manufacturing plants are known as special hazards among insurance men and are given even a greater amount of detail. In such cases there are noted on the insurance maps all elevators, chimneys and boilers. There are also indicated the number and location of the engines and their indicated horsepower, the location of the standpipes for fire purposes and their sizes, the positions of the fire pumps, the kind of hose in use and its length, the style of lighting apparatus for the buildings, the kind of fuel used and the method employed to heat the buildings. So important are the safeguards against fire considered that every device which lessens the risk in this regard is noted. Thus, the number of buckets and fire pails, the barrels of water, the hand grenades, the chemical fire extinguishers. Very often hazardous risks contain fire alarms, watch clocks and watchmen. These are all indicated on the maps, even down to the tours of duty of the watchmen. When there are automatic sprinklers these are shown with their attendant tanks, whether of pressure or gravity, and the exact water capacity in the number of gallons and the source of the supply.

The dummy detail sheet of an insurance map which accompanies this article may prove interesting. It lacks in the reproduction the various colors that show the kind of materials used in the construction, but gives, nevertheless, a very good idea

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A TYPICAL INSURANCE MAP

of the vast amount of information which an ordinary map contains and the workings of the system. Take, for example, 108 and 110 Robert Street. This is a three-story brick building 39 feet high (it would be colored red on an original map) having a party wall in connection with the adjoining building at 112 (indicated by the thin line) and an independent wall against the alley. The alley wall is pierced by windows on each floor, which are protected by ironclad shutters (indicated by the sign). The windows in the rear wall are not protected (indicated by the sign). This building communicates with 112 (indicated by the sign) on the second floor and the third floor, the opening being protected by standard underwriters' doors having fusible links for fire purposes. This building also communicates with a two-story building in the rear of 111 Grigg Street by an iron bridge on the second floor (indicated). The iron shed extending over the sidewalk would be colored grey in an original map. The alley wall of 108 and 110 Robert Street extends 18 inches above the roof (indicated by the vertical line immediately below the number 108).

This building has a tin roof (indicated by the small circle near the elevator). The openings to the elevator are protected by a rolling steel shutters (indicated by the letters R. S. S.). This building 108 and 110 Robert Street forms one of the peculiar features of insurance maps. Note the diagonal lines which are shown only on stable risks. These indicate that hay and straw form the principal contents of this building.

Take another example at 97 Grigg Street. This building is a two-story and attic building with a hipped roof (indicated by the dotted lines). It is covered with shingles (indicated by the small cross). The wall against 99 Grigg Street is a party wall (indicated by the single line) on which the thicknesses are "strad-

dled." The wall against 95 Grigg Street is an independent wall (indicated by the heavy line). Note the gasoline tank with its capacity indicated, the forge in the basement of 97 Grigg Street. The absence of any signs indicating fire walls shows that the roof of this building rests over the supporting walls. The cornice is of frame construction (indicated by the dotted lines immediately in front of the building). The triangle in the rear of 114 Robert Street indicates an iron framed mansard roof. At 104 Robert Street the dumbwaiter is indicated by a crossed square and is of frame construction. The dumbwaiter at 103 Grigg Street is in a brick shaft (indicated by the heavy lines surrounding it) and has metal doors (indicated by the curved line).

Take another example. The Savoy Hotel, 48 to 54 Watling Avenue, is a ten-story apartment house 106 feet high (indicated by signs). It is fireproof, as would be shown by the color brown on an insurance map. The circle at the rear of the elevators indicates a standpipe, to which is connected 75 feet of 2½-inch hose on each floor (indicated). The double circle on the Grigg Street side of this building indicates a "siamese" or fire department connection with the standpipe. This Savoy Hotel has a laundry on the roof structure (R. S.), a baker's oven and kitchen in the basement, a restaurant and café on the first floor (all indicated). The skylight in the rear is protected by a wire screen over the first floor (indicated by signs). The skylight in the marquee on Watling Avenue is of wire glass (indicated by signs). There is a fire alarm at the corner of Watling Avenue and Grigg Street (indicated), a double hydrant (indicated by the black circle with projecting marks). The boilers in the basement are of 100 horsepower each (indicated). The parapet or fire wall extends three feet above the rear wall (indicated by the six ver-

tical lines between the numbers 95 and 97).

The use of these insurance maps is universal among insurance underwriters at the present time. Hundreds more are employed by commercial bodies, boards of trade, real estate men, lawyers; in fact, by all persons and corporations who have need of an exhaustive description in a succinct form of the buildings in a city or town in which they are interested.

Entirely apart from the relation which such maps have to the fire protection of the localities to which they relate, they might be utilized to frame a rational plan for the improvement of the various districts of a city. If the danger risk from fire is so clearly defined by the character of the neighborhood as the insurance map indicates, it is evident that the

nature of the buildings and occupations which should be eliminated are no less plainly shown. Town planning is a subject which can be treated in a very scientific manner when the work is to be considered from the start, but town improvement and development depend upon a number of elements already in existence, elements which must be studied in their relation to their surroundings and in connection with their influence upon the real value of their neighbors. For this purpose the insurance maps may furnish data and information of a character and nature not otherwise available, and thus serve as invaluable guides to the true road for improvement, both to individuals and to the municipality.

NOTE.—The writer desires to give credit to Mr. C. E. Goad, C. E., for certain historical matter.

MACHINE TOOLS AT THE BRUSSELS EXPOSITION

By J. O. Newman

AS pointed out in our previous article, which dealt with the general scheme of this unfortunate exhibition, machine tools played a considerable part in the machinery sections of the various countries represented. There was much that was new, much that was excellent, and little, if any, that was bad. As most of these machines were housed in the Industrial Hall or in the separate German section, the fire did not touch them at all.

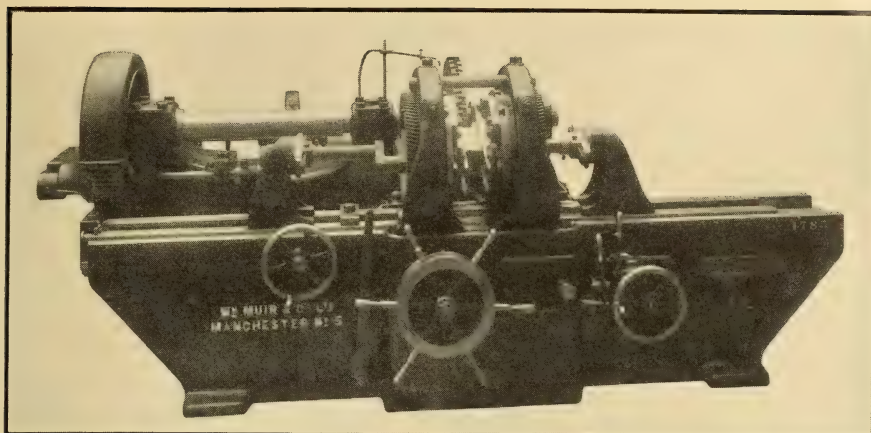
In the British section Messrs. William Asquith, of Halifax, showed various types of their highly finished central trust radial drills in sizes up to five feet and ten feet spindle-radius. Amongst the special features of these machines it may be noted that, as the central trust types of arm adopted do away with side-twisting strains, the work is more accurately performed, the metal is more equally distributed, the endlift is reduced, and while less power is required, the drills being kept steadier, are less liable to breakages. The high-carbon steel spindles can be stopped or started without using either belt or switch, which, when working large objects, means considerable saving of time. The thrust is taken by ball bearings. An improvement is found in a 4 foot 2 inch radial drilling, boring, tapping and studding machine, which is an innovation as far as the central thrust type of radial drills is concerned. In the machine exhibited the spindle slide or saddle is fitted with an additional tapping spindle, by means of which after the hole has been drilled the taps can be brought immediately over the hole without removal of drills or taps, the

hole tapped and the tapping spindle reversed at high speed, and the drilling spindle brought back immediately to proper position again for drilling.

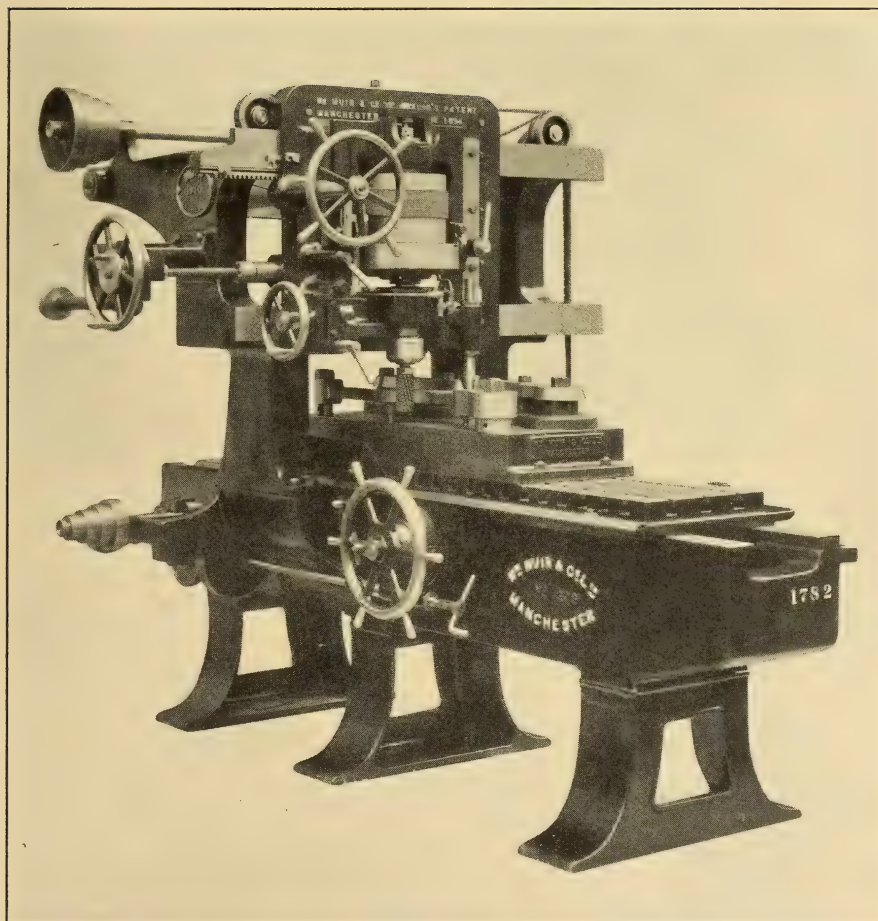
For work in locomotive shops these machines are of the greatest importance; they offer a combination of great rigidity and easy handling, which secures a large productive capacity under conditions where heavy drilling has to be performed in backward positions.

Great credit is due to Messrs. Asquith for their exceedingly well-got-up souvenir, giving an illustrated description of their famous drilling machines. The illustrations are exceedingly well done, and the text being in three languages, sets a good example as to what a catalogue should be.

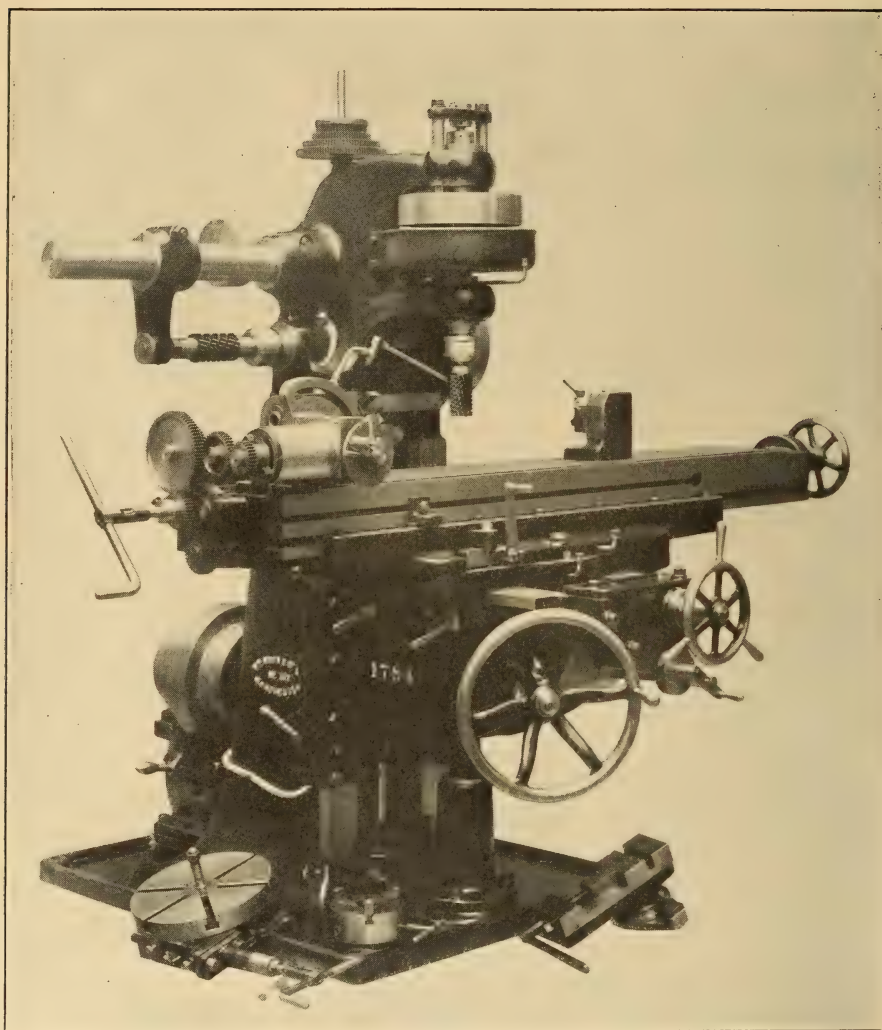
A special crankshaft milling machine of the Melloy type by Messrs. W. Muir, of Manchester, appears to be especially adapted for automatically cutting out the web from the given forging and turning the pin of motor crankshafts. The cutter is of a special design, the teeth are staggered to split up the force of the cut, and it can be adjusted to suit the various widths between the cranksweeps and also to accommodate for their loss in width due to the sharpening of the cutter. The crank is placed in the cup centers of movable hardstocks and can be rigidly clamped to a strong table. On the countershaft are fast and loose pulleys 25 inches in diameter by 6 inches wide, turning at 320 revolutions per minute. Other exhibits of this firm are a universal milling machine, having swiveling headstock, with vertical and horizon-



MELLOY'S PATENT CRANK SHAFT MILLING MACHINE. WM. MUIR & CO., LTD., MANCHESTER



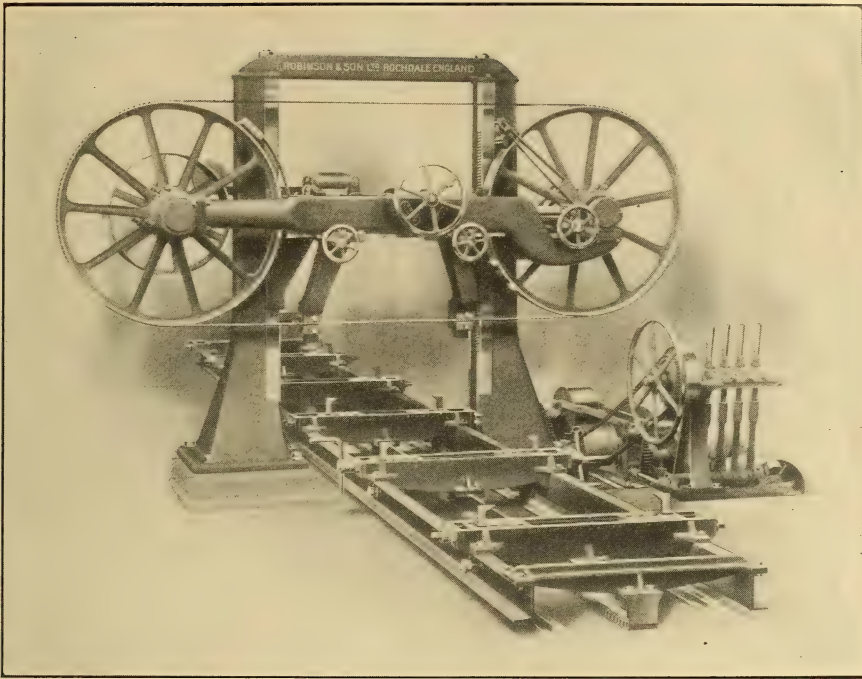
PROFILE AND GENERAL MILLING MACHINE. WM. MUIR & CO., LTD., MANCHESTER



UNIVERSAL MILLING MACHINE. WM. MUIR & CO., LTD., MANCHESTER

tal spindles and dividing heads for wheel cutting, spiraling, etc.; rather a useful tool for a general workshop. There is also a profile and general milling machine with fixed cross-slide and a table 6 feet 6 inches long, exhibited by the same firm. This machine is already well known in engine and locomotive shops and combines the utility of both the vertical and horizontal milling machines; by means of a removable circular table it can be made to operate on any kind of circular work.

Messrs. Thomas Robinson & Son, Ltd., Railway Works, Rochdale, exhibit a horizontal log band mill, a planing and matching machine, a panel planing and thicknessing machine, various band sawing and mortising machines, a two-spindle saw-bench for dimension sawing, especially adapted for the accurate sawing required in pattern and cabinet making, and a universal woodworker, which is a most compact, self-contained plant for general woodworking purposes; it does the sawing,



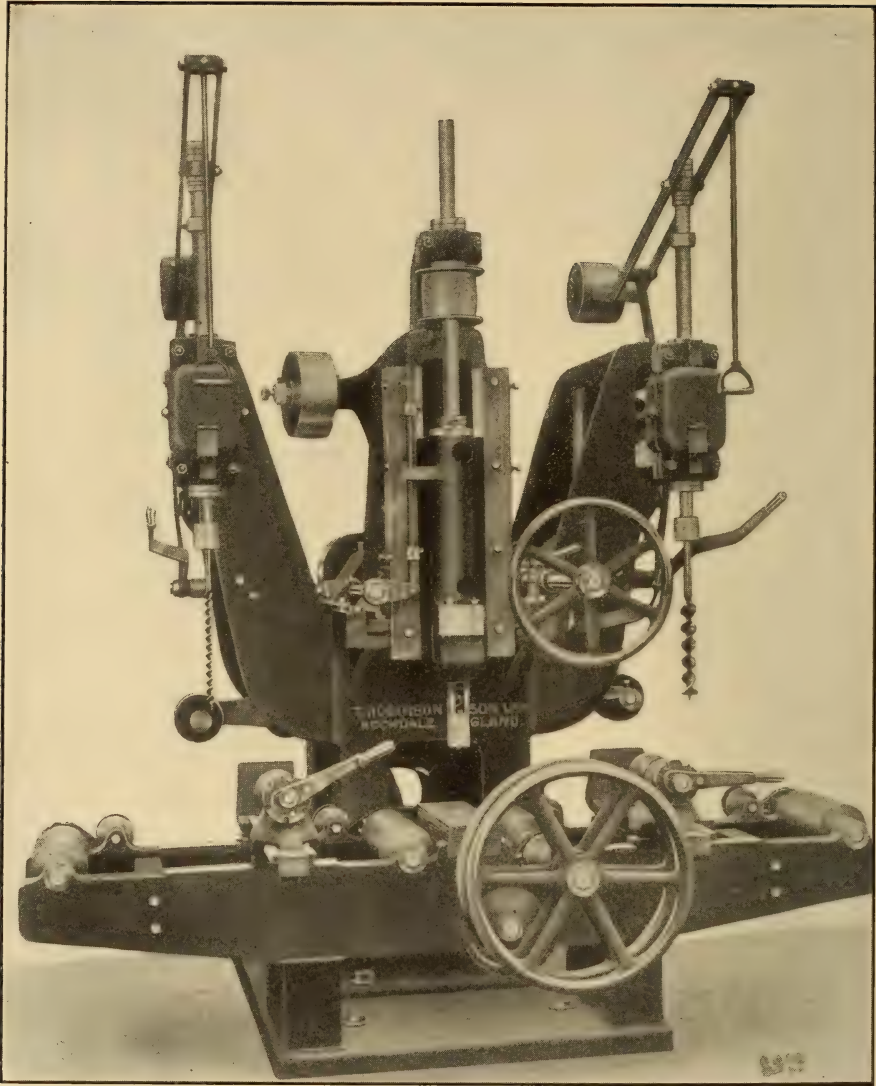
HORIZONTAL LOG BAND SAW MILL. THOMAS ROBINSON & SON, LTD., ROCHDALE

planing, surfacing, rabbeting, chamfering, stop chamfering, tonguing, grooving, heading, straight-moulding, tenoning, slot mortising, boring, etc.

The horizontal log band mill illustrated is adapted for sawing logs of any size up to 36 inches square or 48 inches diameter, and is of a compact, steady and rigid method of construction. There is no mechanism below the floor requiring deep foundations. By means of the new design of the pillars—with the screws placed inside—the distance between the two saw pulleys has been reduced to the minimum and the saw considerably shortened, which should give increased accuracy in the sawing. The vertical guides for the cross-rail, carrying the band saw pulleys, etc., are provided with loose slips to take up any wear that may occur on the vertical slides. Another notable feature is the method of carrying the bearings for the movable saw pulley. The cross-rail is extended and carried under the bear-

ings, supporting the same on flat slides. This method has been adopted to overcome the binding action experienced with overhung bearings carried on circular rams. Another interesting point is found in the method of combining the advantages of both weight and spring for giving tension to the band saw. The spring is interposed between the pulley and the weight, the latter acting through the spring, the combination giving a known tension, due to the weight and an instantaneous action, due to the spring. This new straining device is extremely sensitive. By shifting the weight it can be set to give a suitable amount of strain for saws of different gauges, and any variation due to the expansion and contraction of the saw blade whilst working is taken up at once automatically.

In the large planing and matching machine the feed gear consists of six powerful rollers, driven with machine-cut gearing, the shift of



VERTICAL HOLLOW-CHISEL MORTISING MACHINE. THOMAS ROBINSON & SON, LTD., ROCHDALE

each roller being independent. The gear is simplified by a heavy steel chain, which, running in an enclosed oil bath, connects the feeding-in and tailing-out rolls.

The ram and chisel in the vertical mortising machine have a range of 17 inches and the stroke of the chisel is controlled by a hand lever, by means of which the ram can be started, reversed or stopped at any point of its stroke, a great advantage

when many holes of unequal depths have to be mortised or recessed.

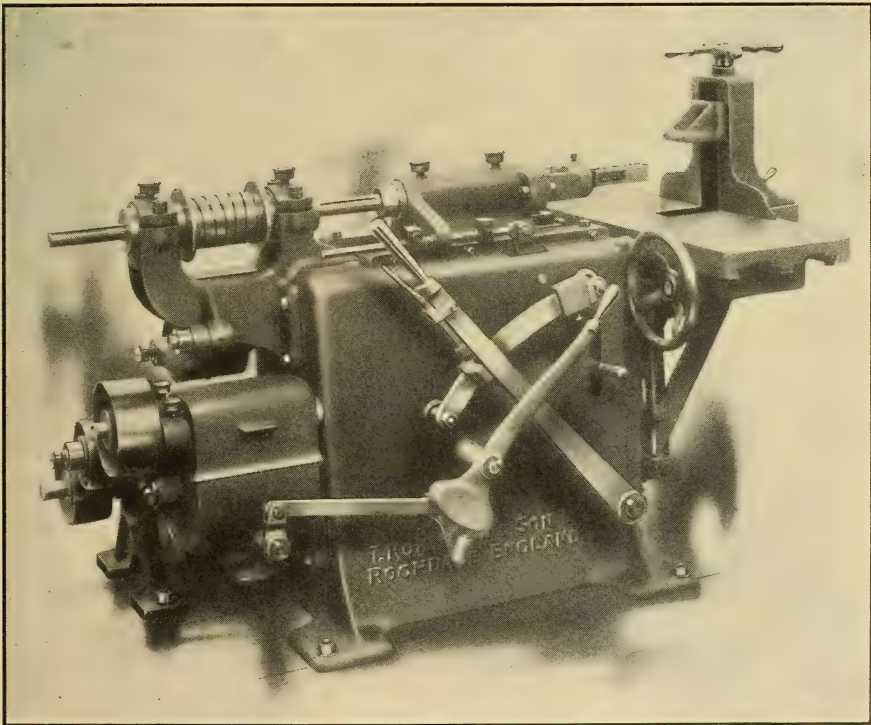
The same firm exhibits a horizontal mortising machine with a square hollow chisel having a special auger revolving inside it. It is specially adapted for cutting blind mortises and square holes and is intended for railway carriage and wagon building. The adjustment and control of the chisel and the feed of the ram are similar to the vertical machine.

Messrs. Butler & Co., Victoria Iron Works, Halifax, exhibit a slotting machine of unique design, driven by a $7\frac{1}{2}$ horsepower variable speed motor. The stroke is 10 inches and the driving mechanism may be described as a slotter link inside the trunk of the machine, to which the driving wheels on each side—eccentrically connected—give an oscillating motion. The tool ram is balanced and there is a relieving movement fitted to the tool-head. The feed is actuated by a cam on the driving wheel and is reversible. The round table has automatic circular and rectangular action.

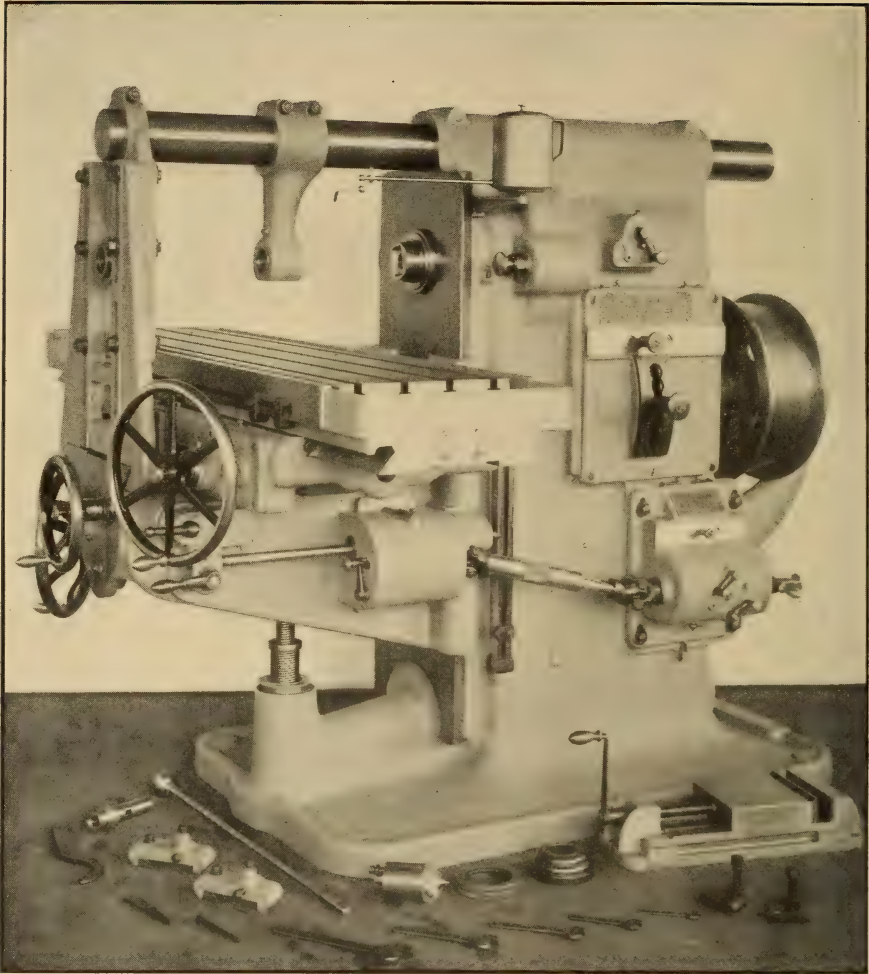
A powerful boring and turning mill for pieces up to 48 inches diameter, by the same firm, is driven by a 15 horsepower motor, driving by a belt to a self-contained countershaft. Fifteen speeds can be obtained by means of five speed cones and two sets of back gears. A similar motor

drives a high-speed, quick-return type planer for work up to eight feet by three feet by three feet. There is also a bar cutting-off machine, direct driven by a $7\frac{1}{2}$ horsepower variable speed motor. A parting tool, which revolves around the bar, will cut through $8\frac{1}{2}$ -inch steel in about 12 minutes. All these motors are by Electromotors, Ltd., of Manchester; the starters being made by the Adams Manufacturing Company, Bedford.

Amongst a large and varied display by Messrs. Kendal & Gent, Ltd., Victoria Works, Manchester, we note a vertical planer milling machine, driven by a 25 horsepower constant-speed motor, for use in locomotive and marine engine shops, where heavy cuts in wrought or steel coupling and valve rods, etc., are required. There are strap-driven and electrically-driven vertical milling machines with automatic (and in the



HORIZONTAL MORTISING MACHINE. THOMAS ROBINSON & SON, LTD., ROCHDALE



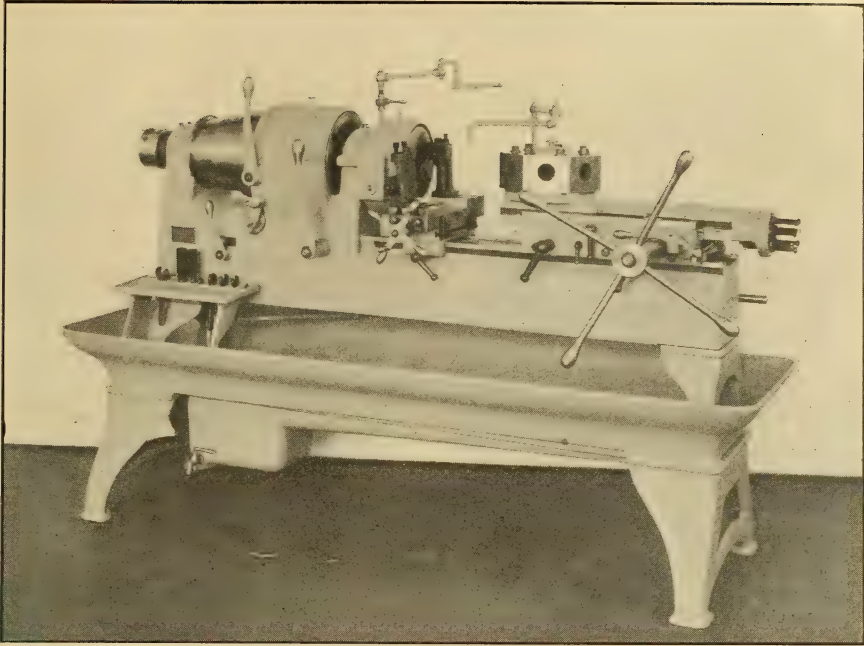
HEAVY PLAIN MILLING MACHINE, WITH CONSTANT-SPEED DRIVE. BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

case of the former additional hand) longitudinal transverse feeding directions, stop and reversing motions.

The radial drilling and tapping machines shown are of the Dixon's patent type. They have two spindles, one for the drilling and one for the tapping, so that the machine need not be stopped when changing from one operation to the other. There is also a nice hexagon turret lathe for making studs, screws and pins direct from the bar, and for work with high-speed tools, and a couple of screwing machines and bolt and nut-screwing machines of the Brown &

Dixon patent type. The latter tool is for screwing two bolts or tapping two nuts (up to $1\frac{1}{2}$ inches) at the same time. Both these tools are adapted for working at high speed and take heavy cuts.

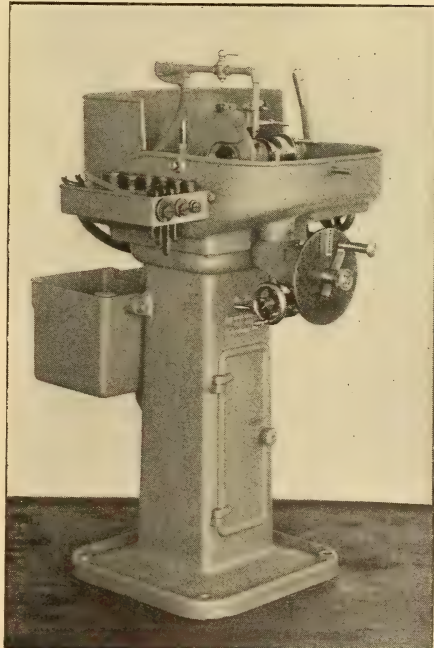
On Messrs. Smith & Coventry's stand we noted a 26-inch machine of a particularly rigid type, especially designed to meet the exigencies of high-speed drilling. There is also a turning and boring mill, admitting work six feet in diameter and six feet in height under the tool holders. This machine has an exceedingly simple arrangement for changing the feed



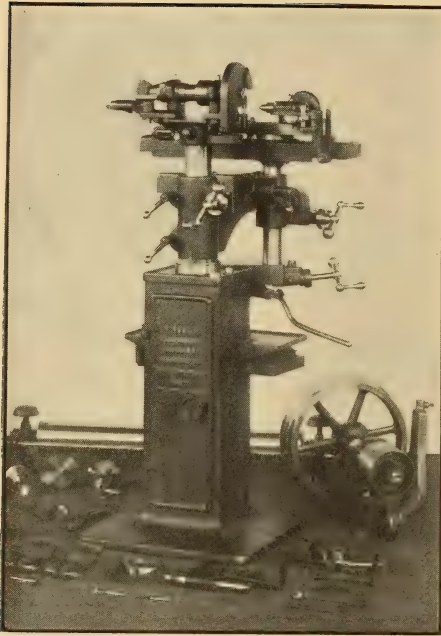
WIRE-FEED SCREW MACHINE. BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

by means of an indexed revolving dial. Another machine for planing at a speed from 15 feet up to 175 feet per minute is fitted with a special driving device, made by the Lancashire Dynamo & Motor Co., Manchester. An economic two-spindle drill press of Rice patent type is fitted with ball bearings throughout, by means of which friction is almost entirely eliminated.

The exhibits of Messrs. J. Rhodes & Son, Ltd., Grove Iron Works, Wakefield, comprise various sheet-metal working machinery, such as: (1) Dies for cutting, forming and trimming the body of a sardine tin in one operation; the inclusion of the trimming being a novelty. (2) Shears for iron, steel or copper up to 14 B. W. G. at 120 cuts per minute. (3) Double seamers for fastening lids and bottoms of the Watne patent type, and (4) a number of power presses. One of the latter is a new form of inclinable press. The centres of crank, couplings and the V's are all in one line, ensuring a central



GEAR CUTTER GRINDING MACHINE. BROWN & SHARPE MFG. CO.



CUTTER GRINDER. CINCINNATI MILLING MACHINE COMPANY

thrust; hexagon lock nuts are used. Generally, in order to have hexagonal lock nuts, presses have been constructed with the coupling projecting beyond the centre of the slides or V's. When the treadle of these presses is depressed the workman can set the dies without throwing the belt off, as in that position the clutch will not engage and no second stroke can be made.

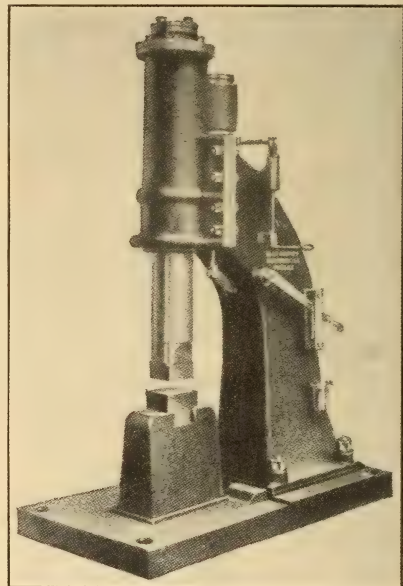
The high-class tool steel of Messrs. Jones & Colver, Continental Steel Works, Sheffield, may come into this section an account of the machine tools installed at this exhibit, in order to demonstrate the properties of their steel. They include a wire testing machine of Messrs. Buckton & Co., Leeds, registering up to 10,000 pounds capacity and a very strongly built milling machine, and a motor-driven lathe of Messrs. Smith & Coventry, Ltd., Gresley Iron Works, Manchester.

Pneumatic power hammers, compressed air hammers, steam hammers and friction drop stamps are shown

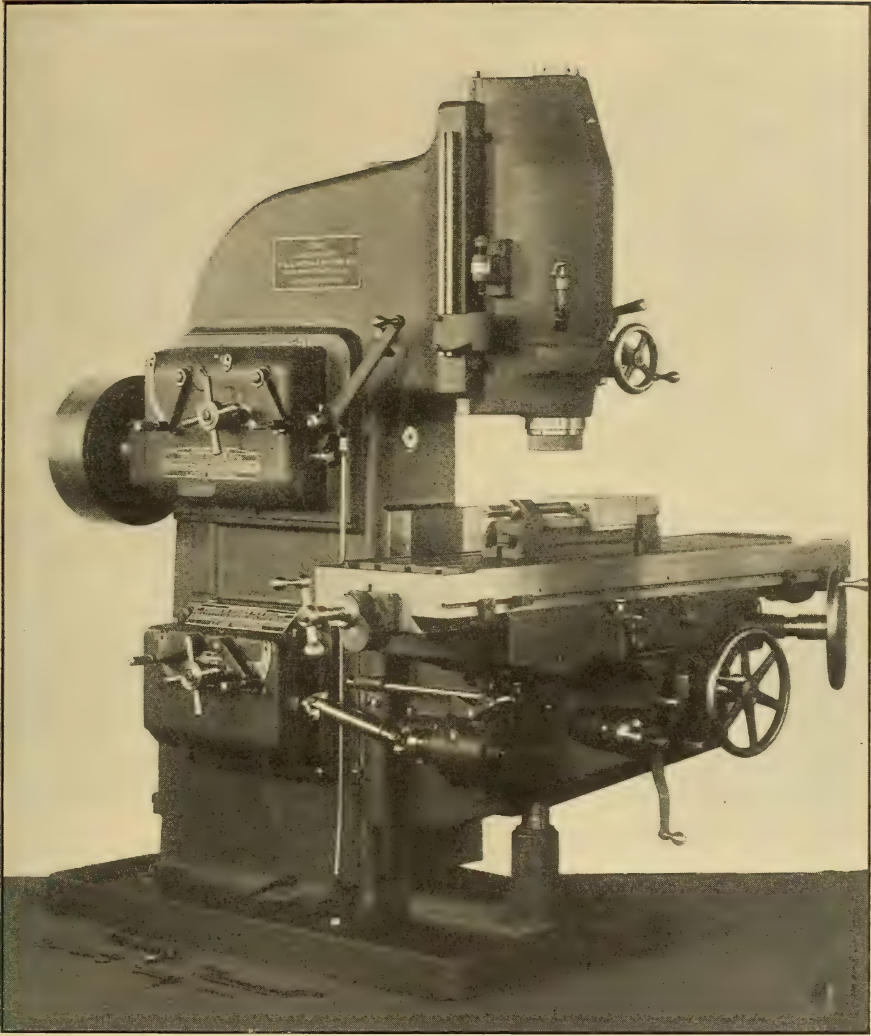
by Messrs. B. & S. Massey, Openshaw, Manchester. The pneumatic power hammers can be driven by a belt or by a motor through gearing. The pump itself is driven by a forge steel crank and connecting rod. The whole device is, of course, more complicated in construction than the compressed air hammers, which are driven from a separate compressed air supply. They are quite equal to steam hammers as far as control and adaptability are concerned, and the simplicity of their design is shown in our illustration.

Messrs. Reavell & Co., Ranelagh Works, Ipswich, besides their quadruplex compressors of various types, show a complete set of pneumatic tools in operation, and Messrs. Lacy-Hulbert & Co., Westminster, exhibit various air compressors of the Bo-veas type. Amongst the specialties in gas and water tools exhibited by Messrs. William Kenyon & Son, Ltd., Chapel Field Works, Duckinfield, we may mention some mouthpiece-facing machines under pressure connections.

From the above short description



COMPRESSED AIR HAMMER. B. & S. MASSEY, OPENSHAW, MANCHESTER



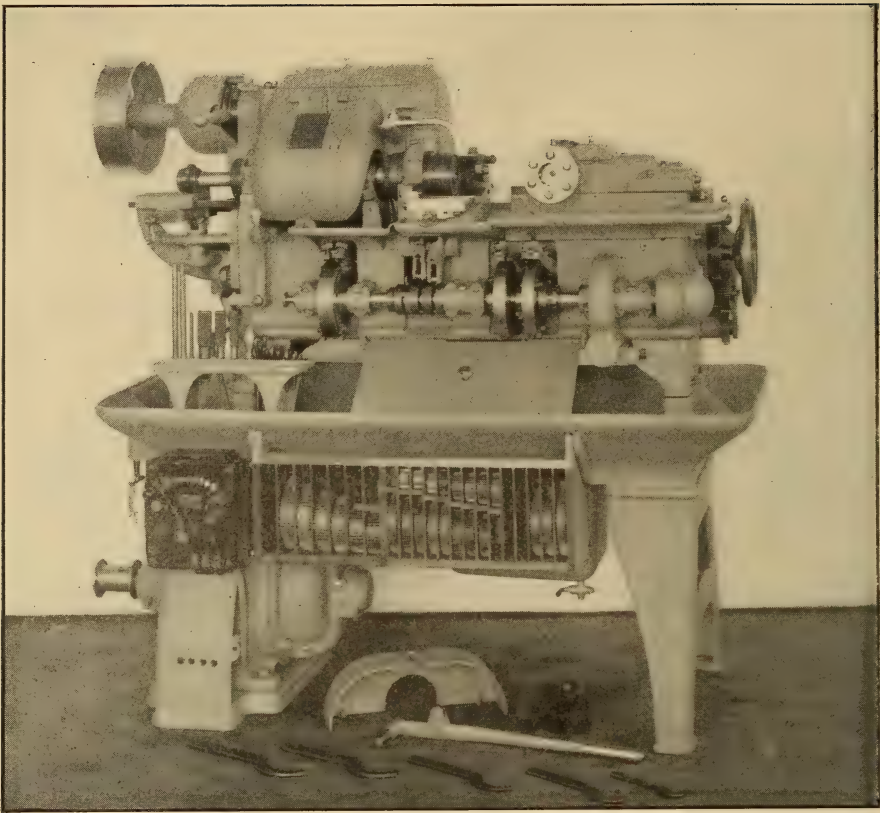
VERTICAL MILLING MACHINE. CINCINNATI MILLING MACHINE CO., CINCINNATI, OHIO

it will be seen that the British machine tools, exhibited at Brussels, both as regards variety and importance, cover a much larger field than has ever before been deployed by Great Britain at any other exhibition, while we have it on the word of many experts from various countries that the finish and excellence of the workmanship of these tools is of the highest character obtainable.

The American section, although small, is particularly rich in examples of high-speed, labour-saving devices

of great accuracy; a principal feature is that the American-made machine tools are very compact and take up only a very small floor space.

Messrs. Brown & Sharpe Manufacturing Company, Providence, R. I., shows a number of heavy universal milling machines, a vertical spindle milling machine with circular milling attachment, universal and plain grinding machines, automatic gear-cutting and screw machines and a wire feed screw machine, gear cutter grinding machine, universal and tool grinding



AUTOMATIC SCREW MACHINE, WITH ELECTRIC MOTOR DRIVE. BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

machines and a universal cutter and beamer grinder and a great variety of attachments.

One of the most interesting of the machines exhibited is an automatic screw machine for constant driving. This machine has a hole seven to eight inches in diameter through the largest feeding finger and turns out any length to $2\frac{1}{2}$ inches, while any length to eight inches can be fed. There are twelve changes of speed, ranging from 119 to 1,216 revolutions per minute. The movements are easy of access and can be quickly adjusted. The same may be said of the feeding mechanism, which can be stopped independently of the spindle. It has a scale graduated to thirty-seconds of an inch. The cross-slide tools are on separate slides and they, as well as the turret-slide, can be

operated by hand. The gears provide for making 7 to 600 pieces per hour, and the feeding mechanism has an automatic stop, which acts when the stock is exhausted and leaves chuck open. The machine takes up very little floor space and does its work accurately and neatly.

A wire feed screw machine, roller fed, shown on the same stand, automatically compensates for ordinary sections in size of stock. There are 3 speeds of countershaft, 12 changes of the spindle speed direct, 30-450 revolutions per minute, 6 reversal, 63-450. The turret is automatically clamped. It has seven 2-inch holes, the greatest distance between turret and front of chuck is 25 inches, and that from centre of holes to top of slide $3\frac{5}{8}$ inches. There is an independent stop for each hole in the tur-

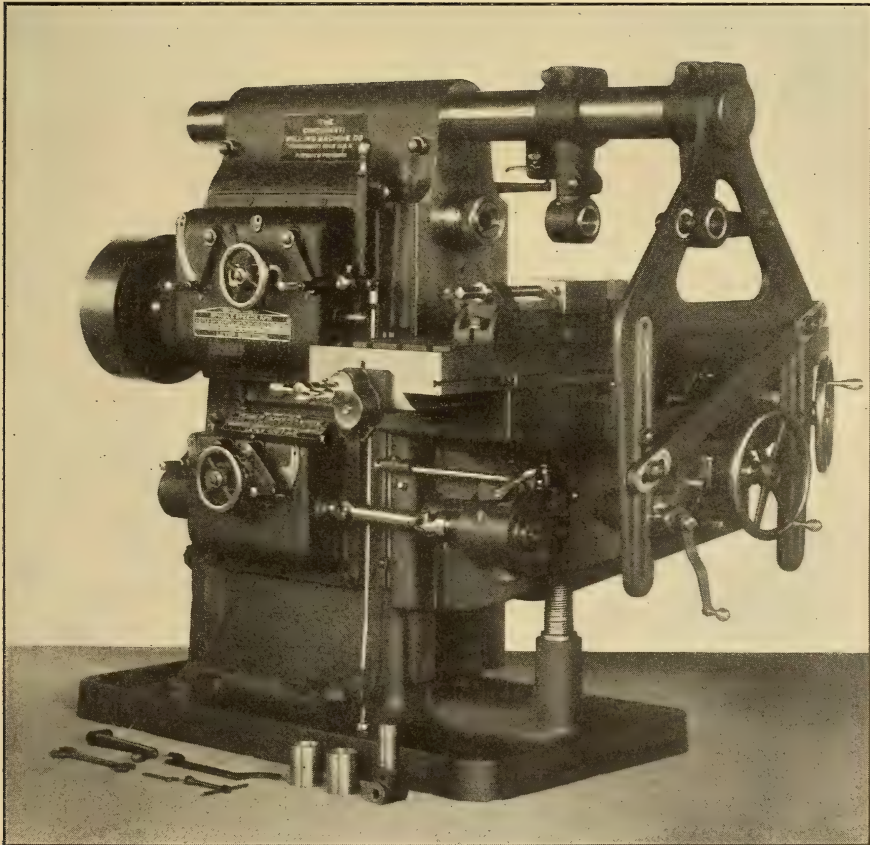
ret, this greatly facilitates the setting of the machine. An ingenious gear-cutting machine, taking up less than a square yard of floor space, is also shown. This machine will grind gear cutters, radial as well as many varieties of formed cutters, up to 8 inches in diameter, $2\frac{1}{4}$ inches thickness and $1\frac{1}{2}$ inch pitch. The counter-shaft is provided with one tight and one loose pulley of 6 inches diameter for 2-inch belt. The machine runs at 600 revolutions per minute.

We noted a similar arrangement on a most useful universal cutter and reamer grinder for sharpening straight and taper shell or shank reamers or shank reamers, and for grinding edge and bevel cutters of any angle, straddle and face mills and straight and taper milling cutters,

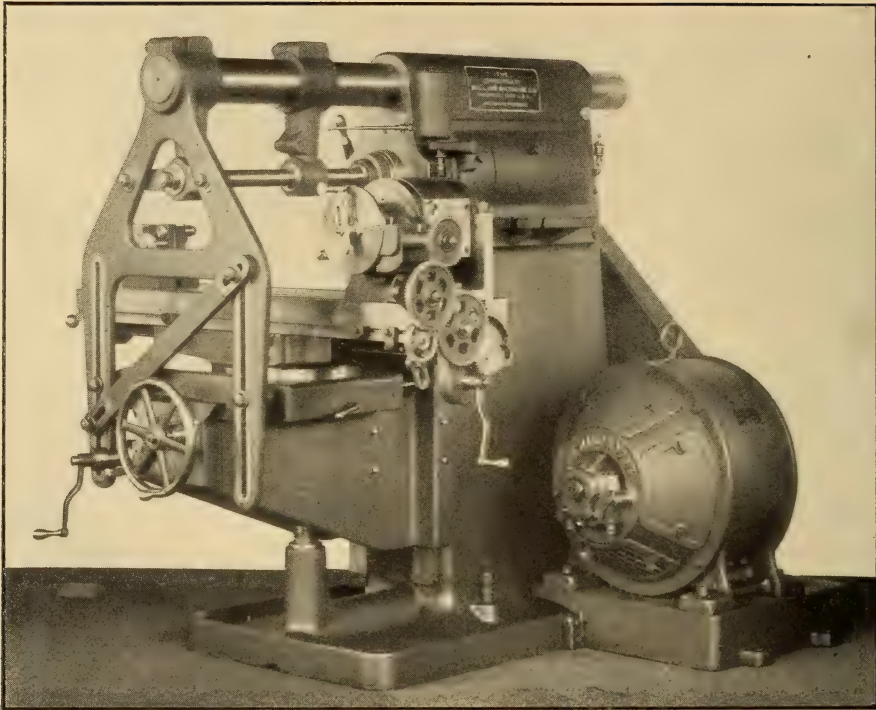
cut either straight or spiral, with holes and shanks. The machine can be further used for sharpening worm or thread tools. Another universal grinding machine exhibited swings 12 inches in diameter and takes 40 inches between centres. The counter-shaft takes a $3\frac{1}{2}$ -inch belt. The automatic cross-feed is extremely accurate and has a range of .00025-inch to .004-inch at each reversal of the table. As it forms an integral part of the table, it can be set easily.

A very heavy plain milling machine, driven at constant speed by a 20 horsepower motor, is shown in actual working. The feeds are speed gears, driven by chain; there are 16 changes, which can be made by adjustment of index slide and lever.

Amongst the many attachments



PLAIN MILLING MACHINE. CINCINNATI MILLING MACHINE CO., CINCINNATI, OHIO



UNIVERSAL MILLING MACHINE, WITH DIRECT CONNECTED ELECTRIC MOTOR. CINCINNATI MILLING MACHINE CO.

shown was a neat circular milling and dividing attachment and several very handy slotting and universal milling attachments, applicable to a large variety of work.

Messrs. Pratt & Whitney have a universal rectifying machine with an automatic sizing device of a new design, a very heavy revolving lathe and a vertical grinding machine.

A shaping machine by Messrs. Walcott & Wood of unique construction deserves special notice.

Messrs. Potter & Johnston exhibit a large variety of semi-automatic machine tools and lathes.

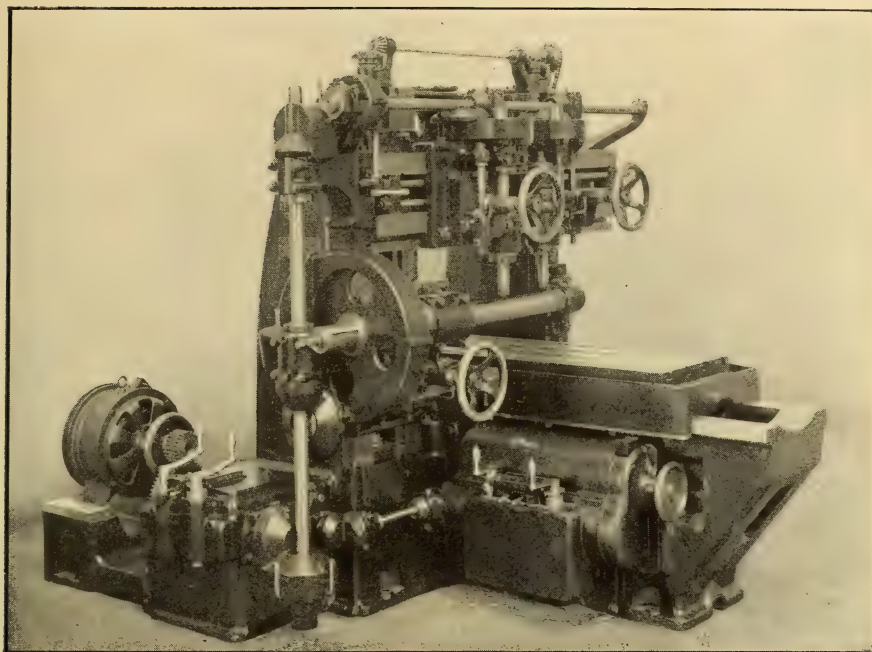
The Cincinnati Milling Company have a good selection of gear-cutting machines, both of the vertical and the horizontal types.

Messrs. Barnes & Fosdick show their drilling machines, and Messrs Warner and Swasey revolving turret lathes.

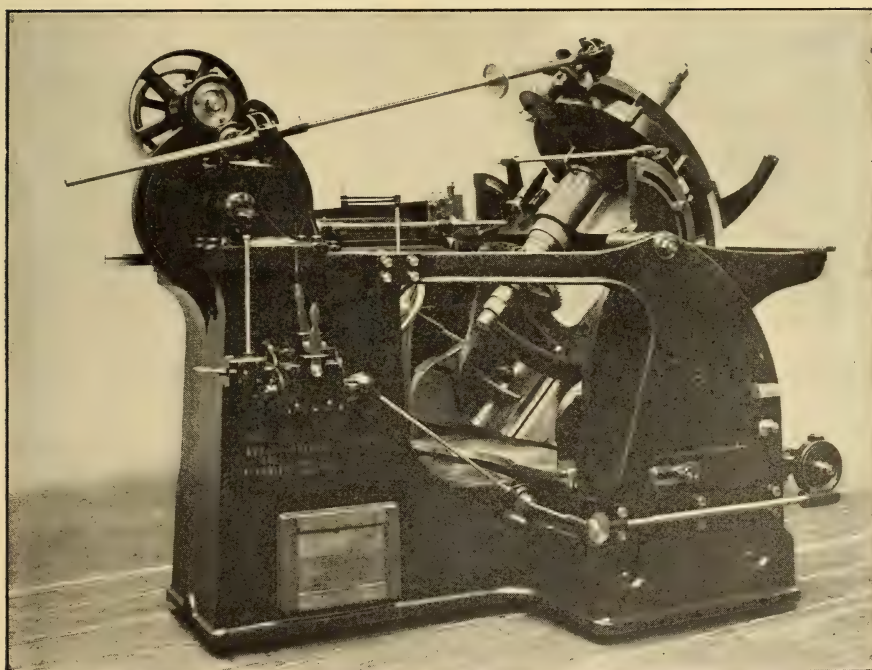
The German makers of machine

tools specialize to a larger extent than the English or American makers. Some firms restrict themselves entirely either to drills, saws, hammers, grinders, lathes, etc.

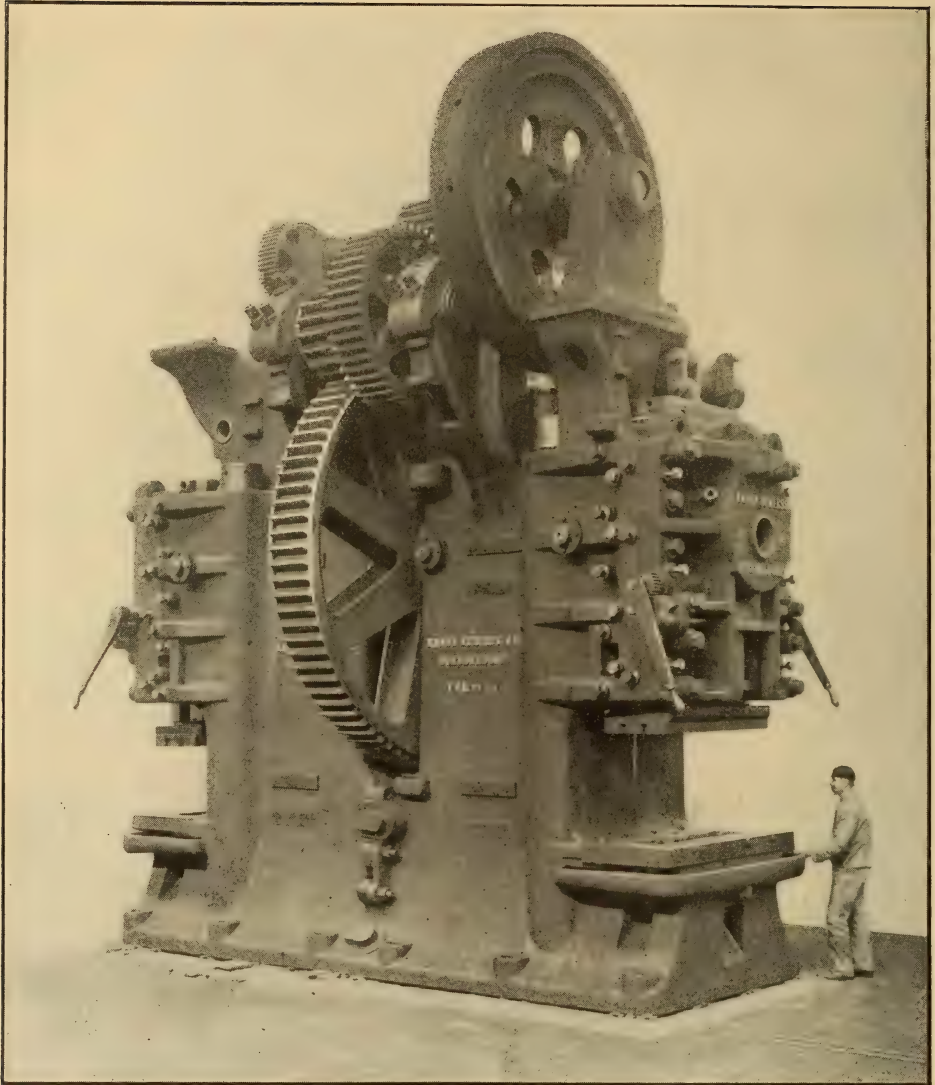
An important collection shown by J. E. Reinecker, Chemnitz Gablenz, comprises milling and gear-cutting machines and lathes and grinding machines of particularly solid construction. The automatic speed gear-cutting machines, by means of which all prime numbers up to 50 and their multiples up to 400 can be milled, are remarkable for the large diameter of their dividing wheels, the powerful drive to the milling cutter and a handy arrangement of the outer arbor support. As the dividing worm can be easily disengaged, the blank can be turned freely to test whether it runs true. The cutter is set to its exact position by means of a fine gauge, a screw and graduated disk controlling the accuracy and depth of



VERTICAL SLAB MILLING MACHINE. J. E. REINECKER, CHEMNITZ-GABLENZ



UNIVERSAL BEVEL-GEAR CUTTING MACHINE. J. E. REINECKER, CHEMNITZ-GABLENZ

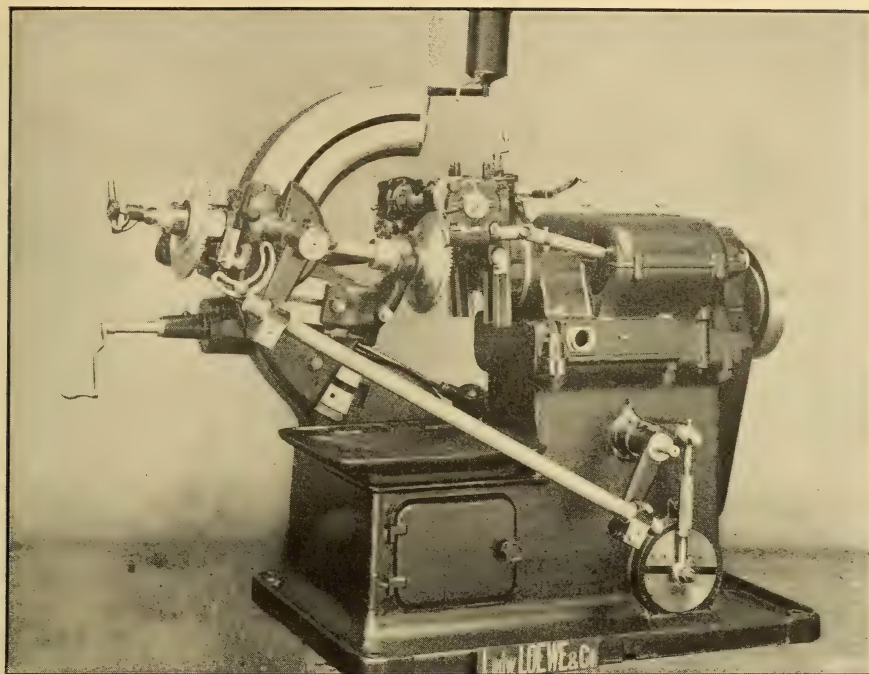


DOUBLE PUNCHING PRESS. ERNST SCHIESS, A. G., DUSSELDORF

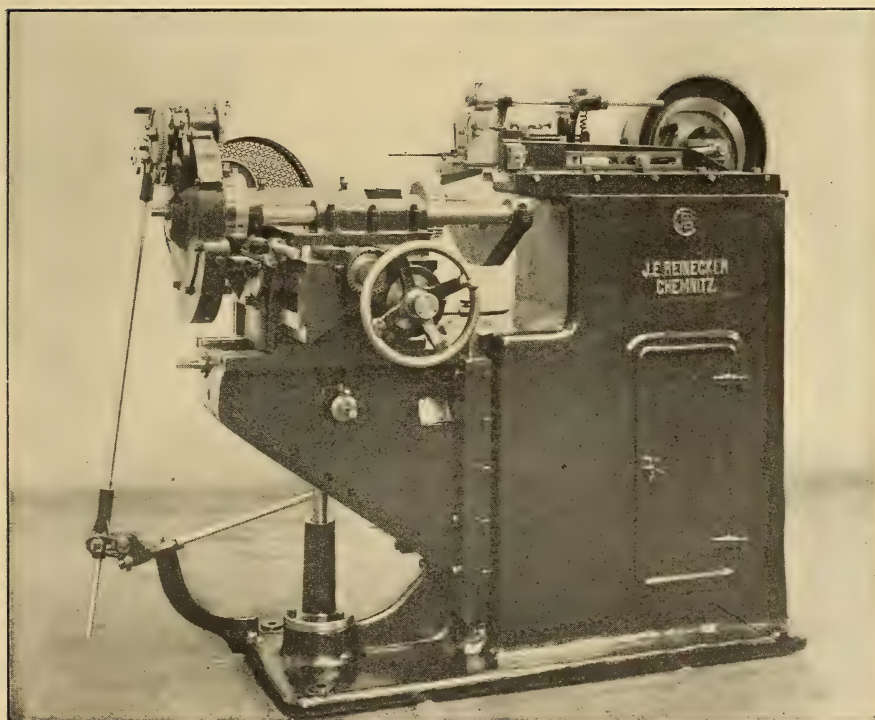
the cut. Our illustrations show a universal bevel gear planer for diameters up to one mètre, a new type of automatic spur gear planer for diameters up to 400 mm. A universal gear-cutting machine for hobbing spur and worm gears and for cutting spiral gears up to one mètre diameter for electric driving, a vertical slab milling machine of recent design and an extremely elegant high-speed sliding, surfacing and screw-cutting lathe for work up to one mètre.

There is also an improved type of parallel milling machine, in which the outer support of the cross-rail has been removed to allow of better access to the spindles. On these machines both parallel surfaces are milled at the same time, tending to absolute accuracy, besides saving considerable time.

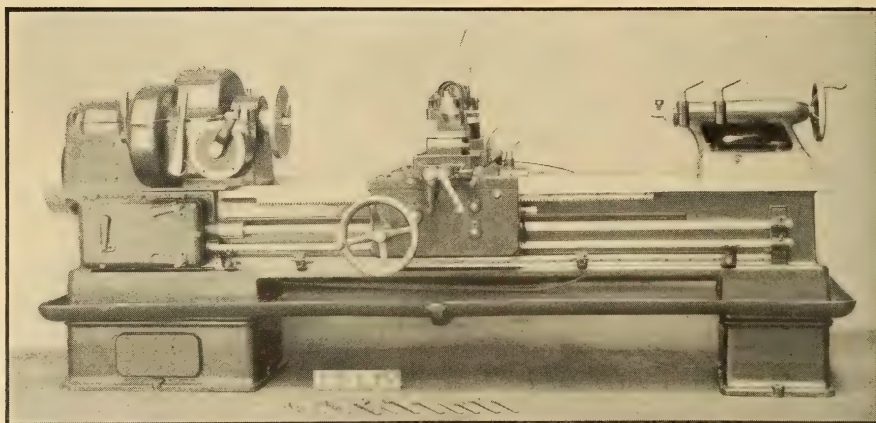
Herr Reinecker is to be congratulated upon the general excellence, not only of his exhibits, which cover the whole field of tools for the construc-



BEVEL-GEAR CUTTING MACHINE. LUDWIG LOEWE & CO., BERLIN



AUTOMATIC SPUR-GEAR PLANING MACHINE. J. E. REINECKER, CHEMNITZ-GABLENZ

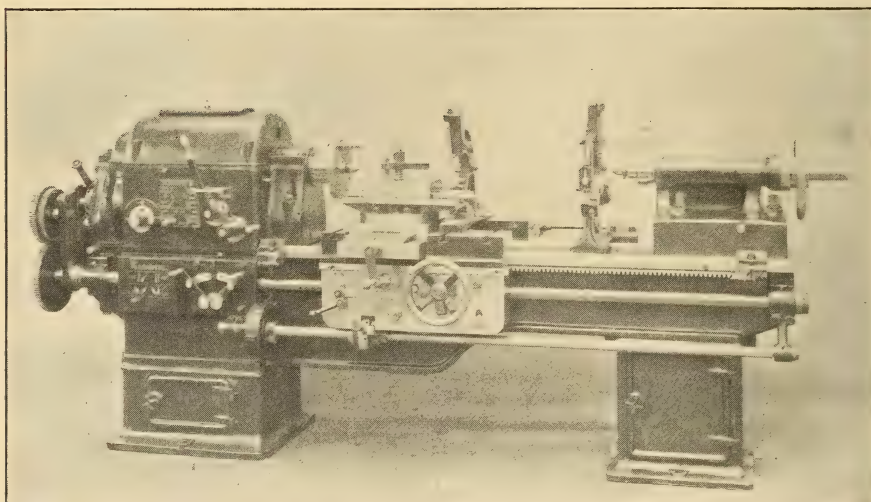


AUTOMATIC HIGH-SPEED LATHE. LUDWIG LOEWE & CO., BERLIN

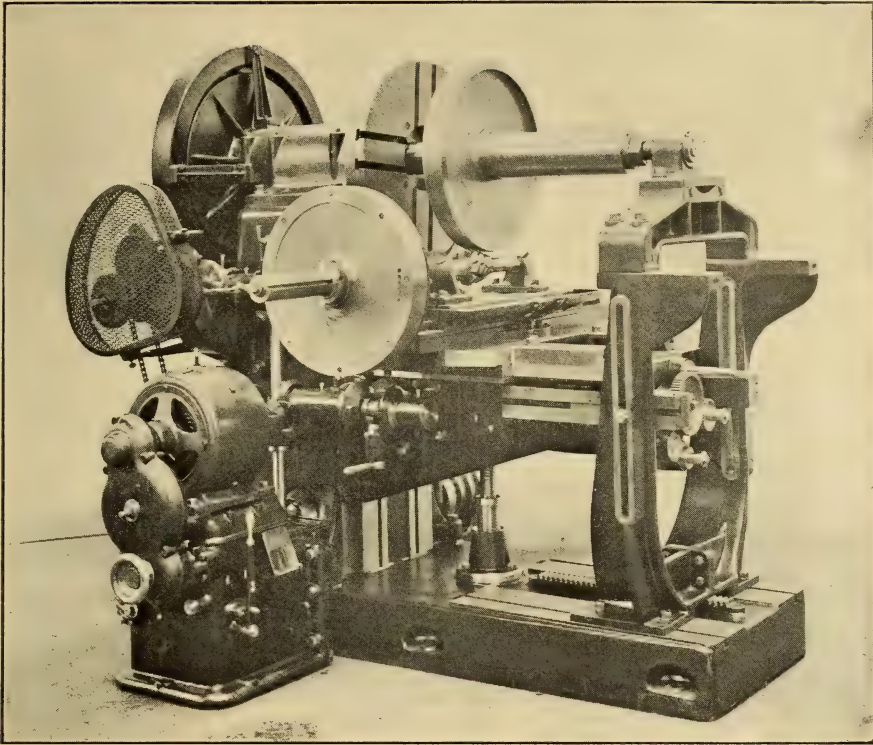
tion and repair of machines, but also upon his thoroughly well-got-up catalogues.

Ernest Schiess, Werkseugmachinenfabrik, Düsseldorf, exhibits special tools for armour plates, iron and steel works, railway repair shops, etc. Foremost amongst these we note a double punching press of most massive construction for a maximum pressure of 800,000 to 1,000,000 kg.; a useful tool for the manufacture of fish-plates. This machine is by far the largest machine tool in the whole exhibition. It weighs about 167,000

kg., and is driven by an electric motor of 110 to 120 horsepower, which moves the flywheel shaft by means of wheel gear. The rams are counterbalanced by double levers and weights and make about 16 strokes per minute, the eccentric stroke of the same being 140-180 mm. This machine has a capacity of 220 square centimeter shearing surface and 45 kg. strength. This firm was the first to introduce planing machines, in which the drive is obtained from an automatically reversing electric motor through powerful wheel gearing,



HIGH-SPEED SURFACING AND SCREW-CUTTING LATHE. LUDWIG LOEWE & CO., BERLIN



UNIVERSAL GEAR CUTTING MACHINE FOR HOBGING SPUR AND WORM GEARS. J. E. REINECKER,
CHEMNITZ-GABLENZ

large pinion and rack, entirely without belting, and they show an example in an open-side machine for 6,000 mm. planing length, 2,000 mm. width and 1,750 mm. height. The width of the table is 1,550 mm., and it will be seen that the bed rests entirely upon this foundation.

An electric motor of 15 horsepower only is employed to drive, what is comparison, an enormous piece of machinery, which can, however, also be belt-driven. This is a vertical turning and boring drill, constructed by Ernest Schiess, and intended for work upon cylinder cover, piston rings, boiler ends, carriage wheels, etc. It has two vertical standards, which are bolted to the base and cut in one piece with the cross-rail, which carries the tool holders.

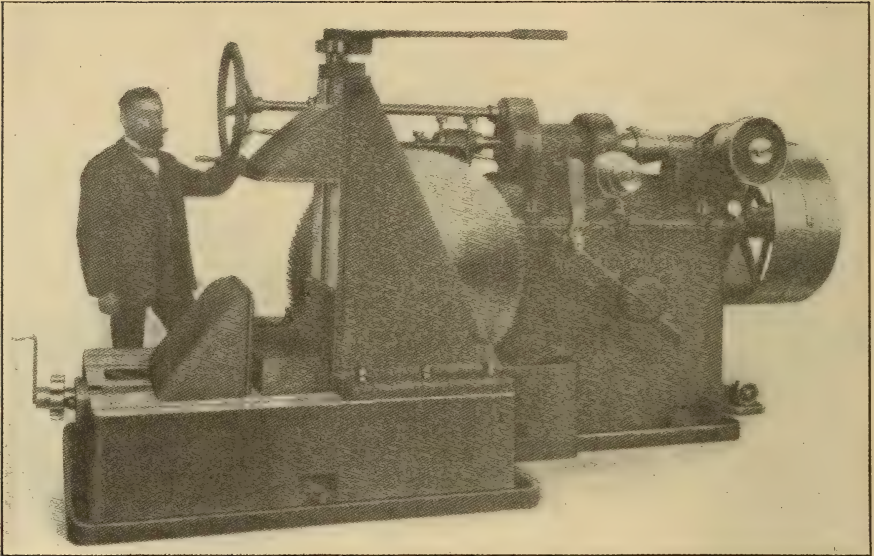
Gustav Wagner, Reutlingen, exhibits a number of cold saws. We

illustrate one of the double type. These machines have a special patent spindle, which gives automatically, and this acts continuously on the surface which is being sawed. We are informed that these machines can saw through Siemens Martin steel of 100 mm. thickness in one minute, and will perform this operation in only two minutes when running continuously.

Amongst the exhibits of Collet & Engelhard, Offenbach a M., we notice especially some very solidly constructed universal radial drilling machines and universal shaping machines of the transportable type.

Another portable vertical boring machine is shown by Droop & Rein, who also show a more powerful high-speed drilling machine of the stationary type.

A number of automatic revolving lathes are shown by Ludw. Loewe &



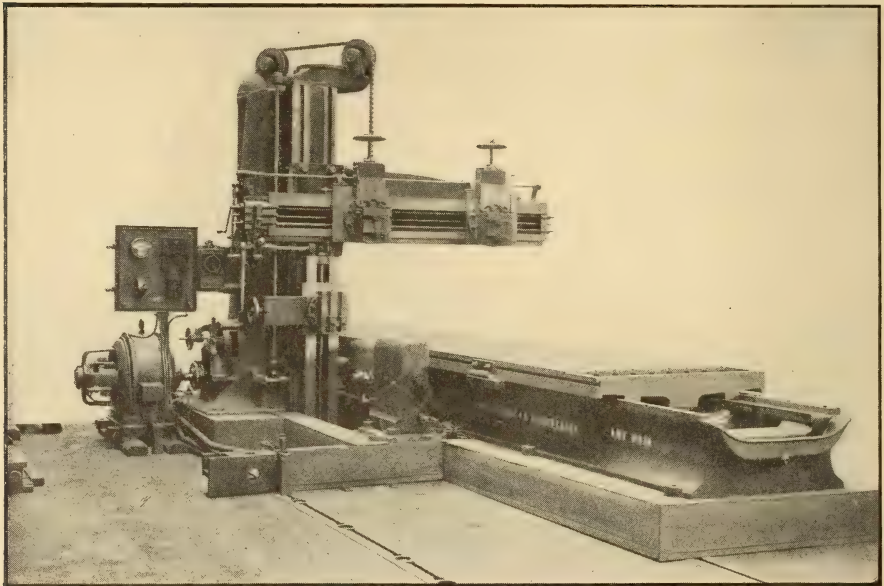
HIGH-SPEED COLD SAWING MACHINE. GUSTAV WAGNER, REUTLINGEN, WURTEMBERG

Co., Berlin. One of these shown is of somewhat similar design to a large high-speed lathe exhibited by J. A. Maffei, Munich. Messrs. Loewe have adopted a new principle in the construction of their bevel gear-cutting machine of the Warren type by

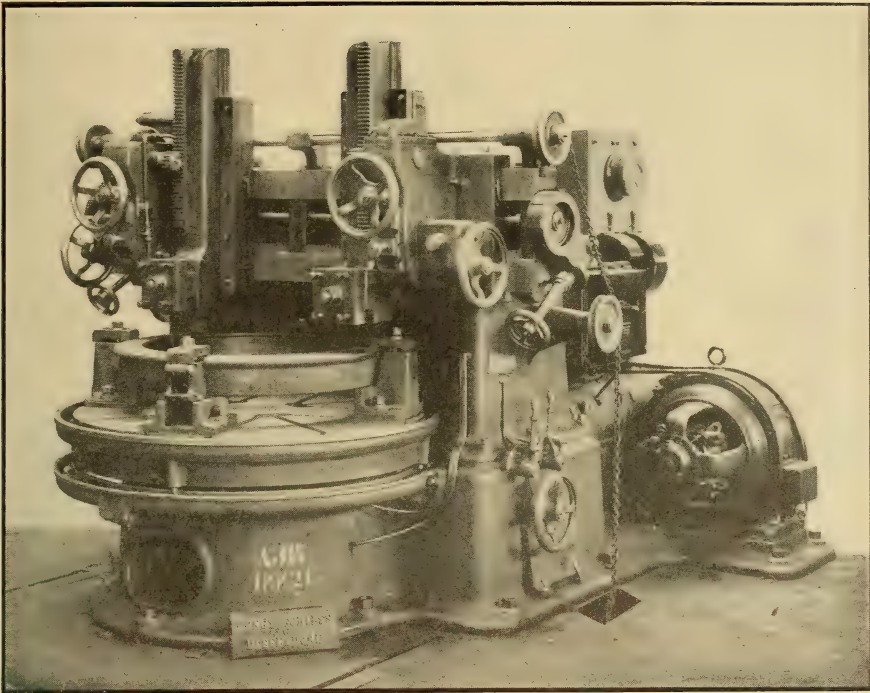
adopting a cutting action somewhat on the Beale principle.

Messrs. Mayer & Schmidt, Offenbach a R., have an automatic machine for cylinders with an arrangement for grinding conically.

A new type of machine for closing



SINGLE STANDARD PLANING MACHINE. ERNST SCHIESS, A. G., DUSSELDORF



VERTICAL TURNING AND BORING MILL. ERNST SCHIESS, A. G., DUSSELDORF

sealing tins is exhibited by Kircheis, Ainé, who claim that one machine will deal with 20,000 medium-sized round preserved food tins in 10 hours.

J. A. Maffei, Munich, exhibit air hammers with two separate cylinders and double action.

Amongst the many special tools, those employed in the woodworking industry are particularly remarkable.

Going through the Belgian machine tool exhibits one is struck more by the infinite variety of machines for the various purposes required which are shown than by any particular novel construction. An exception to this rule may be made with regard to woodworking machinery, of which the works of Ch. Dankaert & E. Menning are the principal exponents. Liège has sent perhaps more representatives than any other Belgian town, and lathes and grinding machines are shown by Fétu-Defize, Jasper, Longdoz and the

Progrès Industrial Works, of that town.

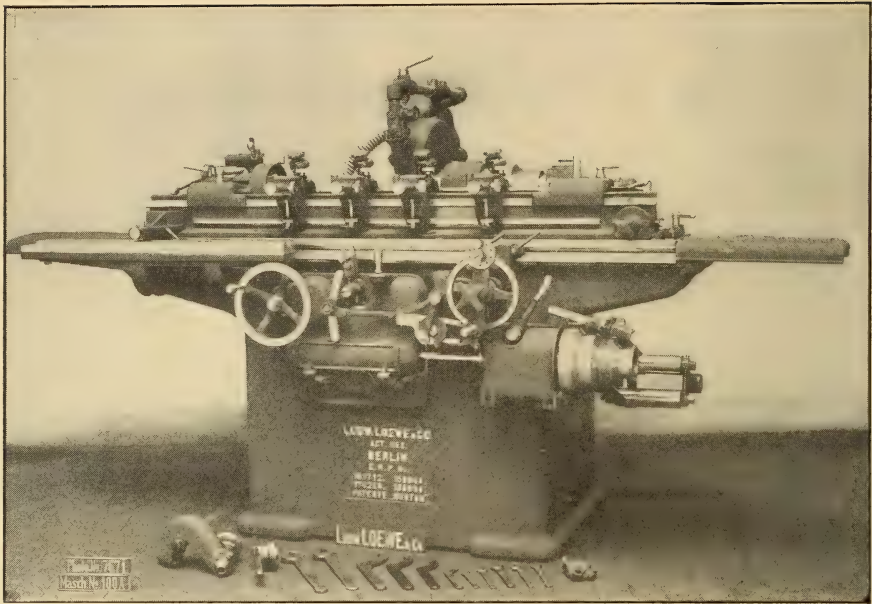
Some very heavy presses are shown by the Ateliers de Construction de la Biesme.

Amongst Brussels' firms we note lathes by Demoor and small presses by Despaigne.

A large variety of mostly vertical shears, drills, stamps, hammers and other sheet-working machine tools are collected in an exhibit by Bliss & Cie., Paris. This firm is well known for their "inclinable" presses. Some of these are fitted with Wilzin compensators.

A graduating machine by Barriquand & Marre with a scale down to .0001 mm. received much attention. One of the best exhibits in the French section is that composed of the various woodworking devices made by Panhard & Levasseur.

The Vienna Carborundum Works have a very neat and simple automatic saw sharpening machine for



AUTOMATIC LATHE EXHIBITED BY LUDWIG LOEWE & CO., BERLIN

circular and band saws, the change from the former to the latter position being readily effected. The grinding wheel is raised automatically by means of an eccentric, and the adjustment of the saw-blade for the next cut takes place simultaneously with the raising of the grinding wheel, so that the wheel grinds along the back of the teeth and retains as a result of its own wear a sharp cutting edge. The machine is driven direct from the shafting and does not require a special countershaft. When the machine is once started it requires practically no attention besides the adjustment of the blade

after one cut has been made round the entire saw, and this readjustment can also be effected automatically by the special vertical adjusting arrangement.

The foregoing account by no means exhausts the machine-tool exhibits in the exposition. To do this is beyond the scope of a magazine article. But we trust that while pointing out the main features and describing some of the most interesting tools to those who were unable to visit Brussels, it will also serve to reinforce the recollections of those who were able to examine the exposition in person.

ENGINEERING AT THE SHEFFIELD MEETING OF THE BRITISH ASSOCIATION¹

AT the recent meeting of the British Association for the advancement of science, held at Sheffield, there were a number of papers presented before the Engineering Section which are of interest to the profession.

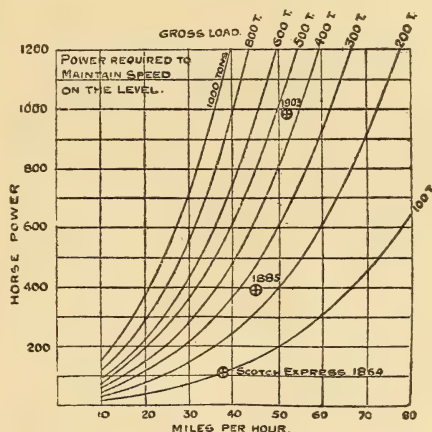
The following report contains abstracts of the more important of these and some details of the subjects which are of greater importance.

BRITISH RAILWAYS

The opening address of the Engineering Section was delivered by Professor Dalby, Dean of the Faculty of Engineering in the newly-constituted University of London, his subject being: "British Railways—Some Facts and a Few Problems."

Much that was contained in Professor Dalby's address has already been covered by various authorities in the Special Railway Number of CASSIER'S MAGAZINE,* but a few points were touched upon that deserve the attention of our readers. Commenting upon the large part played by the railways of the United Kingdom in national life, Professor Dalby stated that the aggregate capital invested was nearly twice the amount of the national debt, while the gross income of all the railway companies was within measurable distance of the national revenue; and the people employed on our railways were over six hundred thousand in number. As regard coal consumption, this amounted to eight million tons per annum, and as was shown later on in the address, owing to the high rate of combustion, fully one-third of this coal was wasted either in the form of ejected coke and cinders

or by the escape of unconsumed hydrocarbon gases. Discussing the increasing weight of trains per passenger and the demand for high mean speeds, Professor Dalby exhibited the following diagrams to illustrate the enormous increase of engine power required to meet these demands.



POWER REQUIRED TO HAUL RAILWAY TRAINS

Typical trains in 1864, 1895 and 1903 weighed 100 tons, 250 tons and 460 tons respectively, and their average speeds were 38, 45 and 52 miles per hour. The power required to work this train (the Scotch Express from Euston to Carlisle) has increased, however, ten-fold, from 100 horsepower to 1,000 horsepower in the same period of time.

A valuable section of the address was devoted to characteristic energy curves of steam locomotives, these diagrams being based, as Professor Dalby candidly admitted, upon the results of experimental trials with locomotive boilers carried out at the St. Louis Exhibition, no similar tests

* See June issue, 1910.

having ever been made in England. The most interesting facts revealed by this investigation were: (1) that the very high rate of combustion in locomotive boilers led to great loss of heat due to ejection of *unburnt* solid and gaseous fuel; and (2) that the rate of heat transmission through the boiler plates was practically constant at all rates of combustion.

The remainder of Professor Dalby's address dealt with the applications of electricity to railway working, and with systems of power signaling, electro-pneumatic signaling and automatic signaling, all of which have quite recently been described and illustrated in our pages.

TESTING LATHE-TOOL STEELS

A paper upon a "New Method of Testing Lathe-Tool Steels" was contributed by Professor Ripper of the Sheffield University, and the method was afterwards demonstrated in the Engineering Department of the same university. The method may be best described in the author's own words:

A testing lathe sufficiently large for the purpose, and driven electrically, is so fitted as to be capable of a very fine adjustment of speed of rotation. The tool to be tested is started on a standard cut—say $\frac{1}{2}$ by $\frac{1}{12}$ —in the testing lathe at a surface speed of, say, 30 feet per minute, and the cutting is allowed to proceed under a gradually increasing rate of speed by equal increments of one foot per minute, each minute throughout the test, until the tool breaks down. That is to say, the speed increment is increased gradually and regularly while the test is proceeding, in the same way as the load increment is increased in the tensile test of a steel bar in the testing machine. Then, if the mean cutting speed in inches from start to finish of the trial be multiplied by the area of the cut, the result is equal to the number of cubic inches of material turned off by the tool during the test, and this is the measure adopted for the merit of the tool.

A lathe specially built by Messrs. Buckton & Co., of Leeds, for this work has been erected at Sheffield, in the Engineering Department of the University, and is run by two direct-current motors—one a 40 horsepower motor, arranged for the main drive, and the other a 5 horsepower motor for operating the feed mechanism. An old ship's shaft has been purchased and cut up into lengths, in order to obtain a supply of uniform steel for making the tests, and the large number carried out so far prove the method to be quick and reliable.

REPORTS ON COMBUSTION AND GASEOUS EXPLOSIONS

Two exhaustive and valuable reports upon the above subjects were presented and discussed in Sections A, B and G. One of these dealt with the chemistry of combustion and the part played by moisture and electrically-charged gas-films in promoting and accelerating the combustion process, and the other with the more practical problems met with in gas engine practice.

The latter report, which formed the third prepared by a special committee appointed by Section G for investigation of the subject of gaseous explosions, was summarized by Professor Bertram Hopkinson and dealt chiefly with the practical effects of radiation. Reference was made to a recent experiment by Hopkinson, in which an explosion vessel had been plated with silver on the inner surface and identical gas mixtures had being exploded in it: (1) with the lining highly polished; and (2) with the lining blackened over with lamp-black. It was found that the maximum pressure was higher by 3 per cent. and the subsequent rate of cooling reduced by one-third with the highly-polished interior, thus confirming the practical belief that polishing the interior of the combustion chamber tends to increase the efficiency of the gas engine.

Reference was also made to the

part played by radiation in determining the heat-flow in a boiler, and to the recent report of Professor Dalby to the Institution of Mechanical Engineers on this subject. Helmholtz's work upon the amount of radiation from flame and the nature and origin of radiation is also discussed in the report, which contains much matter of the highest importance to engineers interested in gas engine design and working.

THE TESTING OF FILES

Professor Ripper, of the Sheffield University, gave some particulars of improvements to the Herbert file-testing machine which have removed the earlier objections to its accuracy and reliability.

The machine, as originally constructed, was defective in one important point, namely, that in the machine the file moved across the face of the test-bar, through an absolutely constant path, the respective teeth of the file each stroke working in identically the same grooves or furrows on the face of the test-bar, stroke after stroke. The result was that the face of the work occasionally became glazed in appearance, and the files ceased to cut though the file itself might not be worn out. In the case of hand-filing, no two strokes were made in exactly the same direction. The conditions, therefore, under which the tests were made in the machine, differed from those under which the file was worked in actual practice, and this difference worked, in some cases, to the disadvantage of the file.

For the purpose of removing this objection, Professor Ripper has devised an addition to the Herbert machine, by means of which the path of the file in the machine is no longer a constant one, but changes its direction stroke by stroke as in the case of hand-filing. To secure this, the file is no longer held rigidly at its two ends, but is connected by ball-joints, the effect of which is equivalent to that of a wrist-move-

ment at each end of the file. The variation of the path of the file each stroke is obtained by slightly shifting the position of one end of the file relatively to the other end by a simple mechanism during each return stroke, so that on the following working stroke it moves in a different path from that which it had in the preceding stroke. The means by which this movement is obtained were explained and illustrated by diagrams.

The addition of this arrangement to the Herbert file-testing machine has resulted in the removal to a large extent of the irregular results previously obtained from files of similar quality.

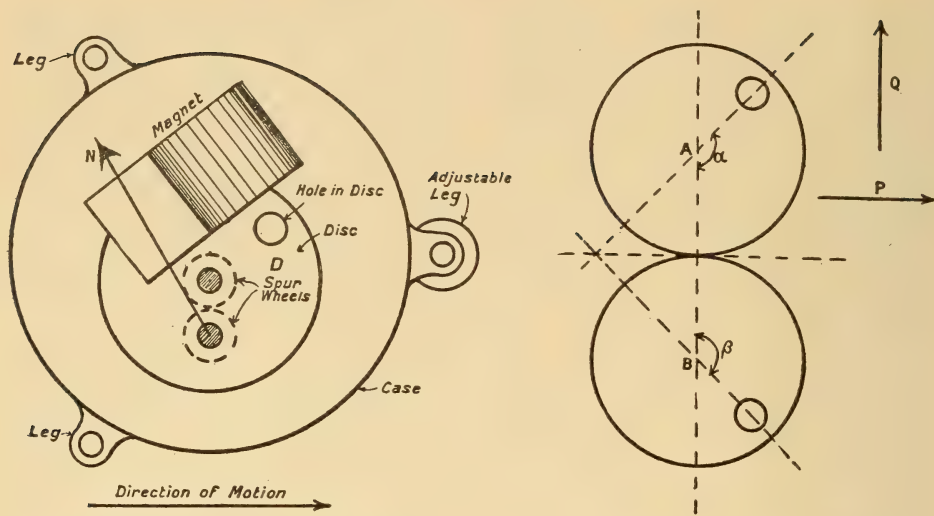
Mr. Philip Dawson presented a paper describing the electrification of the London, Brighton & South Coast Railway, this being in the form of a lecture illustrated by lantern slides.

The special feature of interest in this lecture lay in the account of the practical work of the overhead equipment, which has been found entirely satisfactory, notwithstanding the disasters which had been prophesied.

Professor Silvanus Thompson mentioned the fact that he had recently inspected the working drawings of a 2,000 horsepower electric motor for locomotive service, this being believed to be the largest electric motor yet built for this purpose. Both of these communications show that the single-phase alternating system for electric traction is meeting with practical success in actual service.

A NEW ACCELEROMETER

Mr. Wimperis gave a description of a new form of accelerometer invented by him for the measurement of road resistances and horsepower. This proved to be one of the most valuable and interesting of the papers presented at the Sheffield Meeting of the Association. As Professor Dalby stated in closing the discussion Mr. Wimperis has succeeded in solving a problem which many, including him-



THE WIMPERIS ACCELEROMETER

self, had been working at for some years, while Professor Perry further commended Mr. Wimperis by stating that his invention represented a striking combination of scientific ability and common sense and would find a wide field of usefulness.

A diagrammatic representation of the mechanism of the instrument is shown in the illustration. To make a measurement of the tractive effort necessary to overcome the resistance to motion, the instrument is leveled on the floor of the car by means of the adjustable leg, and then when the car is coasting the indication of the needle gives the reading in pounds per ton. The general nature of the internal mechanism may be described as a lop-sided copper disc, mounted on a vertical axis and controlled in its rotation by a coiled spring. Any acceleration causes the heavier side of the disc to lag behind and so partially wind up the spring. The degree to which the spring is wound up measures the acceleration. Any tendency of the disc to oscillate is checked by a magnetic field at right angles to the plane of the disc. Besides these parts there is what is called "the compensating balance," which causes the instru-

ment to record absolutely correctly, even when traveling around railway curves, or when on a road heavily cambered to one side or the other. The copper disc is shown at D; it has a hole cut in it near the circumference, which has the effect of throwing the center of gravity slightly out of the center of the figure. On the pivot of the disc is fastened a spur wheel which gears in with another equal spur wheel, mounted on a parallel axis and carrying the pointer N. This pointer moves over a scale, not shown in the diagram. It will be seen that there is a small permanent magnet placed so as to damp the motions of the copper disc without having any of the sticking qualities which accompany frictional damping. The spring, which is coiled up by the rotation of the disc, is not shown, but it lies in the horizontal plane just above the disc. In later forms of the instrument the arrangement described above has been varied slightly, but not so as to affect in any way the general principle of working. It had not been possible to include in the paper a description of more than a few of the tests which have been carried out, but the general conclusions

which have been so far reached may be set out as follows:

(1) By the use of the accelerometer the road resistance of different kinds of roads or tracks, under various weather conditions, can be measured and compared;

(2) The amount of air resistance due to various forms of vehicle can be at once determined;

(3) The mechanical and thermal efficiency of the engine at various speeds can be obtained under real working conditions;

(4) The brake horsepower exerted by the engine when running at various speeds on the road can be easily obtained;

(5) It is possible to trace step by step the losses of power in transmission;

(6) It is possible to make a definite allowance for motor vehicles which are specified to show a given fuel economy (such as gross-ton-miles per gallon of fuel), and which may have to run their tests on exceptionally heavy roads;

(7) Lastly, the use of the accelerometer enables a useful interpretation to be given to speed and efficiency tests which are carried out on specially prepared motor tracks, having characteristics different from those of the ordinary highway at unrestricted speeds.

CYCLICAL CHANGES OF TEMPERATURE NEAR THE WALLS OF A GAS ENGINE CYLINDER

Method of Measuring Air Supply to a Gas Engine Cylinder

Professors Coker and Dalby contributed papers on these important details of gas engine working, of which the following are abstracts:

Experiments described in "Engineering" for October, 1908, show that the temperature at the inner surface of a small gas engine is about 240 degrees C., and the cyclical variation is usually less than 10 degrees C.

The steady conditions of low temperature at the wall-surface are

maintained by the jacket-water, although the explosion of the gaseous mixture produces very great changes of temperature close to the walls.

This variation has not hitherto been measured for a complete cycle owing to the difficulties which occur in measuring the highest temperature of the explosion. In order to obtain the cyclical variation near the walls, a couple was made of an alloy of 10 per cent. iridium and platinum, with a pure platinum wire, and this was secured in a metal plug so that it projected $\frac{1}{4}$ inch into the cylinder. On light loads and weak mixtures the cycle remained unbroken, but near full load the platinum wire melted.

Couples made from 10 per cent. alloys of iridium and rhodium with platinum were afterwards used, having an electromotive force E above 500 degrees C. given by $E = -174 + 7.6075 T - 0.00167 T^2$, where T is the temperature centigrade. The junctions were rolled down to five or six ten-thousandths of an inch thickness and inserted at a depth of $\frac{1}{2}$ inch from the cylinder wall.

These couples were able to withstand the highest temperatures near the walls, and they were not melted except during abnormal explosions.

Measurements of the cyclical variations showed a variation of E. M. F. lying between 1.56 and 7.83 millivolts with an average cold junction temperature of 30 degrees C. The temperature variation corresponding to these values ranges between 250 degrees C. and 1,700 degrees C.

In estimating the highest temperature reached, the upper limit of temperature is indicated by the partial melting of one of the wires when the engine ran above its full normal load, and the lower limit is indicated by the melting of platinum wire. The melting point of platinum is $1,710 \pm 5$ degrees C., and in the absence of definite values of the melting points of the alloys used it is assumed that both are below the melting point of iridium, for which Violle's value is

1,950 degrees C. The probable causes of error in the measurements are discussed and the conclusion is reached that the temperature at the place of measurement has a maximum value between 1,850 degrees and 1,900 degrees C.

An orifice in conjunction with an anemometer was used to measure the air supply at the Ashton trials of the Committee of the Institution of Civil Engineers, and more recently Professor Ashcroft contributed a paper to the Institution of Civil Engineers describing a method of using an orifice in conjunction with a specially-designed indicator to measure the difference of pressure on the two sides of the orifice. In the Ashton trials the air supply is inferred from the anemometer readings, and in Professor Ashcroft's method the air supply is inferred from the difference of pressure in conjunction with the orifice, which was made about the same size as the suction pipe of the engine, in consequence of which the difference of pressure was very small. In each case calibration was effected by driving the engine from the crank-end, and then from indicator diagrams deducing the weight of air passing through the orifice. This deduction cannot be made accurately unless the temperature can be accurately measured at one point on the indicator diagram. In neither case could this temperature be measured. The gas engine used by the author is fitted with apparatus by means of which the temperature corresponding to the pressure and volume at an assigned crank angle can be accurately measured with a platinum thermometer. Thus all the data are observed from which the weight of air drawn through the orifice per cycle can be computed. Indicator diagrams were taken with an optical indicator giving accurate results. Every indicator card was calibrated for pressure *in situ*. The peculiarity of the method is that a relatively small orifice is used—so small, in fact, that the difference of pressure on the two

sides of it is equivalent to about one foot of water under normal conditions of running. This difference of pressure can then be measured by means of a U-tube, and small variations of head are easily observed. Numerous experiments established the fact that the coefficients of the orifices tried were practically constant and equal to 0.6. The gas supply can be measured through an orifice in the same way. Hence the mixture of air and gas passing into the cylinder can be obtained from two readings, with suitable corrections for density, at any time during the run. The orifices, in combination with their U-tubes, become rate measurers, the one giving the rate at which air is supplied to the engine, and the other the rate at which gas is supplied.

The section upon mathematical and physical science included a discussion upon the subject of mechanical flight, devoted mainly to the question of the use of mathematical principles in the design of flying machines and the possible improvement which might have been made had such been employed in the machines already built. The ultimate conclusion seemed to indicate that the practicability of mathematical methods is so dependent upon constants and coefficients obtained from actual trials that there is little opportunity for their use at the present time in this field.

THE OPTICAL DETERMINATION OF STRESS

Professor E. G. Coker contributed a valuable paper on the above subject, summarized as follows:

The experimental determination of the state of stress in a body by purely mechanical means and apparatus has the disadvantage that it is necessary for accuracy of measurement that a definite length, area or volume be maintained in a standard condition, and the stress at a point cannot therefore be accurately determined if the stress is a rapidly varying one.

The property possessed by glass of becoming doubly refractive under stress has been frequently utilized to determine the state of plane stress at a point in it by the colour fringes produced, but the difficulty of forming any but the simplest objects in glass has prevented its extensive use for experimental work.

Other substances have been tried and a preparation of nitrocellulose in commercial use has been found, which answers exceedingly well for experimental work. Its properties are very different from glass and experiments show that the modulus for tension is approximately 300,000 in pounds and inches, and the value of Poisson's ratio 0.37; plate glass having the corresponding values of 10.5×10^5 and 0.227 respectively. For determining stresses a method of matching colours is adopted, in which a uniformly stressed test-bar is loaded until the colour produced, by the retardation of a plane or circularly polarized ray, corresponds to that produced at a point in the object under stress. The relative retardation (R) of the ordinary and extraordinary rays is assumed to be similar to glass, and to follow the law expressed by $R = C (X - Y) T$, where X , Y are the principal stresses at a point, T is the thickness of the material and C is an optical constant.

The stresses at the cross-section of an eccentrically-loaded tie-bar, and at the principal section of a hook, are shown to be in fair agreement with theory.

To determine the lines of principal stress in a body, the loci of points at which the directions of the principal stresses are the same are found by using plane polarized light, and from the curves so found the directions of the principal stresses are determined.

From the curves of principal stress, coupled with a knowledge of the position of the isochromatic lines, the stresses at any point may be determined by the use of

Professor Clerk Maxwell's method.

After Professor Dalby had given a rapid summary of the contents of his paper on the "Measurement of Air Supply to Gas Engine Cylinders" (already abstracted), Professor Silvanus Thompson followed with a lecture on the "Laws of Electro-Mechanics."

This was a highly technical dissertation, rather more suited for the class-room than to a British Association audience, and none of those present cared to discuss the subject until opportunity had been given of studying the lecture in print.

A paper on "Heat Insulation," by Mr. Francis Bacon, proved to be a description of a new method of testing the comparative efficiencies of heat insulating materials, the work having been undertaken in order to discover the best materials and methods for lagging the walls of cold storage chambers.

The author's description of the apparatus is contained in the following extract from his paper:

"In order to avoid the labour and difficulty of molding the material to be tested into a shell or covering of complicated shape, recourse was had to the more direct "wall" method, in which the drop of temperature between the two faces of a thin slab transmitting a known heat flux is determined. The inherent sources of error to which such a simple method is liable are: (1) leakage of the heat flux; (2) incorrect determination of the temperature of the surfaces. It is claimed that both of these errors have been rendered negligible. In fact, the accuracy with which the heat flux and temperature gradient could be determined was greater than could generally be turned to useful account owing to the want of uniformity existing between two specimens of the same material.

"Duplicate specimens of the material to be tested are obtained in the form of slabs measuring 18 inches by 18 inches and not more than $1\frac{1}{2}$ inches thick. A thin, flat

heating-net of uniformly-wound resistance wire, interwoven with asbestos (those manufactured by Messrs. Schniewindt, of Neuenrade, are excellent for the purpose), measuring 12 inches by 12 inches, is sandwiched in between these slabs, the marginal crack left all round the heating-net being filled up with strips of felt. Direct contact between the heating-net and slabs of insulating material is avoided by interposing a thin sheet of asbestos millboard on each side. To measure the temperature of the faces of the slabs advantage is taken of the fact that there is no perceptible drop of temperature between a heat-insulator and a good conductor of heat in close contact with it. Sheets of zinc 12 inches by 12 inches are taken and a flat resistance coil of fine double silk-covered wire wound uniformly over a central 6-inch square of one of their faces. The wire is wound non-inductively and secured to the zinc plates by stitches of thread passing through fine holes drilled in the metal. Zinc plates prepared in this way are inserted on each side of the slabs of insulation, the fine wire coils being in direct contact with the material to be tested. Thin wood covers are now put on both sides, and the whole is clamped firmly together by four bolts, with wing nuts passing through two skeleton frames of wood. The apparatus is then hung in a vertical plane in a situation screened from draughts and sunlight. The terminals of the heating-net are led away through an adjustable resistance and suitable switch gear to a battery of accumulators. A voltmeter and ammeter are connected up to the circuit, from the readings of which the watts dissipated can be obtained. As the arrangement of slabs is identical on both sides of the heating-net, the heat generated will divide equally, half escaping through one wall and half through the other. The terminals of the resistance of fine copper wire are connected up to a Wheatstone bridge of the stretched-

wire type through a system of plugs, which enables the ratio of resistances of either pair of coils to be determined."

Typical cooling curves for (1) silicated cotton, (2) "Expansit Schrot," (3) an air-jacket, obtained by use of the apparatus and method, were given, and the author stated that the values obtained for asbestos led him to the conclusion that its heat-insulating value was rather due to its fireproof qualities than to its low conductivity for heat, which in fact was no lower than that of wood. An air-jacket also, if there was any opportunity for the rise and escape of the heated air, was a very poor insulator. The specially prepared cork manufactured and sold as "Expansit" was a wonderfully light and efficient insulator and was one of the best he had examined.

A NEW METHOD FOR PRODUCING HIGH TENSION DISCHARGES

Professor E. Wilson, of Kings College, London, and Mr. W. H. Wilson contributed a paper on the above subject, of which the following is a summary:

According to this method energy is taken from an alternating or continuous current source and is stored in a magnetic field by an inductance; it is then permitted to surge into a condenser, which forms with the inductance a *low* frequency oscillatory circuit. When the energy is accumulated in the condenser the latter is mechanically bridged across the primary winding of an induction coil, with which it forms a *high* frequency oscillatory circuit. The energy is then transmitted by the secondary winding of the induction coil to the work circuit and can be of an oscillatory or uni-directional character, according to the purpose in view. The apparatus is light, efficient and cheap, and is especially suitable for radio-telegraphy, X-ray and other work in which high tension electrically is employed.

The final paper was one by Pro-

fessor A. Schwartz, the subject being:

A MACHINE FOR TESTING RUBBER BY
MEANS OF ITS MECHANICAL
HYSTERESIS

The author stated that he had designed a machine in which specimens of rubber of standard dimensions could be loaded at a given rate to a given percentage of their breaking load. The load was then removed at the same rate, and a graphical record was obtained of the extension and retraction curves on the chart table of the machine.

Rubber possessed very considerable mechanical hysteresis, and a consideration of the loop diagrams obtained from the machine enabled the following physical quantities to be determined for any given test piece:

- (1) The rate of extension with load;
- (2) The work done in extension;
- (3) The work done by the rubber in retracting;
- (4) The work expended in the rubber itself;
- (5) The sub-permanent set remaining after a given extension.

The limits of the hysteresis loop might also be set in terms of extension in place of load, as already stated. The author found that for a given rubber the following laws hold good:

- (a) The load per unit area of the

initial cross sectional area of the test piece is constant for a given extension for a given load limit increased independently of the sectional area of the specimen within certain limits;

- (b) The work done in extension, in retraction and in the rubber itself is, within certain limits, proportional to the cross sectional area of the test piece and is directly proportional to the length of the specimen, with a given percentage extension.

On the completion of the first cycle of extension and retraction the specimen might be subjected to a series of similar cycles, the limits of which might be set either by a given maximum extension or by a given maximum load.

For high-grade rubbers the areas of the loops for successive cycles became constant after about the sixth loop, when the subsequent cycle loops were taken up to the same maximum load as that for the first loop.

The author found that the extension for a given load limit increased with each successive cycle and that the rate of increase followed a logarithmic law from the second cycle onwards.

Applications of the hysteresis test were given to the determination of (1) various grades of rubber, (2) of the quantity of rubber in a given mixing, (3) of the degree of vulcanization and (4) of the deterioration due to age or high temperature.

THE RAILWAYS OF BRAZIL

By Lionel Wiener

VIII.—RAILWAYS IN THE STATE OF SAO PAULO

ON the sea coast, Santos, the large and convenient harbour of the whole of the State of São Paulo, lies snugly hidden behind an island. Immediately at the back of Santos and close to the sea shore runs the Serra do Mar chain of mountains, exceptionally forbidding along here, where the plateau ceases abruptly close to the seashore.

In the uplands beyond lies the capital of the State—São Paulo—and further inland the important town of Jundiahy, then Campinas and the world-famous coffee estates.

Five large rivers take their source in the Serra do Mar and run in an approximately east to west direction away from the sea, this being a curious characteristic of all this part of Brazil. The Paranapanéma is the southernmost of these rivers; then comes the Tiété, followed by the Mogy Guassu, the Rio Pardo, and, lastly, the Rio Grande. This latter takes a southerly bend, as it picks up the neighbouring Rio Pardo and Mogy Guassu before it joins the Parana, into which flow the Tiété and the Paranapanéma.

We have, therefore, a zone of hills between Santos and São Paulo, beyond which are four zones or strips of land between the rivers. The hill zone is crossed by the São Paulo Railway, and each of the others is served by an independent railway. As there is but one line that reaches the interior of the State of São Paulo from the sea coast, all the traffic must necessarily pass over it, and it is bound to be the common trunk line for the 3,000 miles of railways of that State, besides those of Goyaz and Matto Grosso beyond. That is

why this railway is unique and can be compared but to one other line of communication—the Suez Canal.

The São Paulo Railway, the fourth in date of Brazilian railways, was incorporated in 1856 for the purpose of joining Santos with Jundiahy, and passing as close as possible to the town of São Paulo, then boasting fewer than 40,000 inhabitants, and then extending on to Rio Claro.

The line was to be built to the 5-foot 3-inch gauge, the early gauge of Brazil, and was granted the usual 7 per cent. guarantee of interest on £2,000,000 capital, the 19-mile protected zone, and a number of other privileges. Should dividends not reach 7 per cent., tariffs might be raised; on the other hand, they were to be reduced should the dividends reach 12 per cent.

The line was opened to traffic in 1867, and was immediately successful. It extended 87 miles to Jundiahy, had twenty-eight stations altogether, and cost £272,816, of which £262,700 had a guarantee of interest.

The expenditure had thus reached £3,134 per mile.

The São Paulo Company, a Brazilian concern of thirty-three years' duration, had been unable to complete the railway, and, as funds were lacking, an English company, still in operation, had taken its place, with a 90 years' lease and interest granted on an additional £62,700 capital.

Besides its unique geographical position, the line has another most interesting feature: a portion, and a long one, is worked as a cable railway—one of the few cases in which a cable is used on a main line. A



short run of 14 miles across marshes takes the line up 65 feet to the foot of the Serra. It was found impossible to secure satisfactory gradients, as the plateau drops abruptly, so the company decided to scale the hills by means of a number of inclined planes, up which the trains were to be hauled by stationary engines, similar to those then at work upon the planes of the Brussels and Liège main line. The gradient there is 1 in 30, and the planes two in number. For some time now powerful banking engines

have been substituted for the stationary engines, which have been done away with, but at the time these were remarkable.

From Pirassununga, at the bottom, to Alta do Serra, on the top, there is a difference of level of 2,570 feet and a distance of about 5 miles. To negotiate them the line was originally divided into four sections, each two kilometers long (6,561 feet), with 1 in 10 gradients, and the trains hauled up by means of a steel cable 1 inch in diameter, working at one-

tenth of its ultimate strength. Hauling was accomplished on the tail-end system.

This cable was made of forty-two strands, and each one was some 200 feet longer than was necessary for the corresponding section.

It ran along the line over pulleys, $8\frac{1}{2}$ and 12 inches in diameter, set about 10 feet apart in the curves and 19 feet in the alignments. At the top it ran onto a guiding pulley 4 feet in diameter, and further onto a sheave or pulley, 10 feet in diameter, with two grooves in the rim; it then passed into an underground chamber, a 12-foot fall, where it was wound around a trebly-grooved similar sheave, forming a bight between the two grooved wheels.

The wheels were driven by a stationary engine with two cylinders 26 inches in diameter by 61 inches stroke, developing 150 horse-power.

Bull-headed rails and Greave sleepers were used at first. The original rails weighed 66 pounds per yard and the later ones 88 pounds. The steepest gradient is 1 in 40, and the sharpest curves 795 feet radius.

The whole of the line is magnificently, even gorgeously, built, and comprises many fine specimens of engineering work, such as the Grotoa Funda Viaduct, 708 feet long, on a steep gradient of 1 in 10 and a curve of 2,000 feet radius, with a maximum height of 170 feet. The bridge over the Casqueiro, just out of Santos, is 495 feet long, on Mitchell piles, which are used also for the Cubataó Bridge, 300 feet long.

There are no fewer than 22 bridges more than 70 feet long and aggregating 6,720 feet, besides 32 bridges of from 10 to 70 feet, adding another 400 feet of bridging, and 354 smaller ones.

This large amount of bridging is due to the very heavy rainfall, and a large amount of special work has had to be done to prevent landslips and damage to the line.

As much as 33 inches of rain have fallen in a single month (January,

1896), and 6 feet in the first three months of 1895. The usual rainfall is from 10 to 12 feet a year.

The Jundiahy tunnel is the longest, 1,551 feet, and there are fourteen tunnels altogether, making a total of 5,715 feet.

Shortly after the opening of the line a Government commission was appointed to look into the working and capacity of the railway. This was in 1866; there were two English commissioners and a Brazilian one. Their report was duly sent in, stating that, without altering the engines then at work, the company could handle 2,504,000 tons a year.

But traffic increased by leaps and bounds, owing to the general prosperity of the State, which had been helped by the opening of the new line, and towards 1891 the road had become absolutely congested. This was a public calamity, as it meant obstruction to the whole of the State of São Paulo.

On July 17, 1895, the company signed a new agreement with the Government, lengthening its lease and confirming its other privileges; on the other part, the company increased its capital by £3,000,000 for improvements, so as to be able to cope with the traffic and prevent the recurrence of the disastrous situation which it had vainly been endeavouring to remedy.

These improvements form really a completely new line. The original road has been duplicated all the way through, forming the only double-track line in Brazil, and is worked on the block system. Bridges have been rebuilt, increasing their strength by 25 per cent., and thus raising the permissible weight limit per axle, while many new stations have been provided, the cost of stations aggregating £595,230 as against the original £59,523, and the cost of the new station at São Paulo alone being £180,000. New repair shops also were built, at a cost of £120,000.

But the principal alteration was the construction of a new set of five

planes worked on the endless-rope system, which has the advantage of balancing the dead loads.

The planes are a couple of kilometers longer than the old ones, with a uniform gradient of 1 in 12.5.

The lengths of these five inclines varies from 6,694 to 6,122 feet, the total being 32,520 feet, with a difference on height altogether of 2,616 feet. The arrangement provides a level stretch of 380 feet and a curve of 145 feet connecting each pair of inclines. The old inclined planes, which are still retained for emergency service, are equipped with a centre rail, as on the Leopoldina Railway, this providing a special grip for the brakes.

The trains take 40 minutes up or down the new planes—a clear 20 minutes' gain on the former timing.

The new hauling ropes are made up of six strands of steel wire on a hemp core; their resistance, when new, is 108 tons, and 72 tons when worn, and as the maximum load on the rope is 18 tons, the coefficient of safety varies from 6 to 4.

The rope is kept taut by an underground tension slide and tension weight apparatus, which returns it from one line to the other and is gripped by a rope grip carried by a special vehicle called the locomotive-brake, which is coupled onto the lower end of the train. This vehicle is fitted besides with the automatic vacuum brakes, and with additional rail-grip brakes as an extra security.

The permanent way is laid with rails of the Vignole type, weighing 93 pounds per yard. The arrangement of tracks is peculiar. Since the trains meet each other only at the middle of the inclined plane and at the ends, it is only at those points that the full double tracking is used. On the rest of the incline the track consists of five rails, only three of which are carrying rails, spaced at the regular gauge of 5 feet 3 inches, this reducing the width of the road-bed by 5 feet 6 inches, the usual interval between tracks.

The power houses are equipped with Lancashire boilers and with steam engines of 1,000 horse-power for driving the hauling rope, the Walker differential drum being employed to equalize the strain on the parts of the rope in the engine house. Each incline has its separate power plant, thus requiring five installations, an arrangement which might have been modified by reducing the separate plants to three in number, one at the top of an incline and another at the bottom of the next, so as to work two consecutive inclines with the same plant. As they are, however, these inclined planes are remarkable, proving the practicability of hauling railway trains economically on grades of 1 in 12.5. In considering the cost of such an installation, the interest on the large extra expenditure required for a system involving ordinary gradients should be taken into account. The trains hauled up these inclines are made up of six loaded freight cars and the grip car, a total weight of 145 tons, the paying load being 78 tons, or 54 per cent. As seven and one-half trips can be made in an hour, it follows that 585 tons per hour can be delivered at the top and bottom of each incline.

About one-quarter of the length of these inclines are either in tunnels or on viaducts, the construction involving 4,000 tons of steel and 6,000,000 cubic feet of masonry. The viaducts range from 102 feet to 627 feet in length, and total 4,552 feet in all, while the tunnels are thirteen in number, from 73 feet to 858 feet in length, with a total of 4,455 feet.

In such a difficult country all work was of a particularly arduous nature. Material for construction purposes before the completion of the inclines was hauled up the 8 per cent. grades by simple adhesion, 0-4-0 tank locomotives, weighing 38 tons. These locomotives could haul a load about equal to their own weight.

The underground power houses were particularly troublesome to lo-

cate. There was no room next to the track, as the precipice fell sheer on the one side, the mountain sloping upwards often at an angle of 45 degrees on the other.

Four of the five power houses are entirely underground, the track being actually laid on the top of the third and fourth power stations. The soil is composed of disintegrated schist, whose condition is caused and aggravated by the exceptionally heavy rainfall to which the Serra do Mar is subjected. Excavating is, therefore, both difficult and dangerous, and was proceeded with in successive layers, each one under the former, as soon as the walls had been sufficiently consolidated and propped up to prevent any slipping. The retaining walls of these power houses reach a height of 56 feet on the valley side, and the mountain side has been laid with dry stone and masonry nearly to the top.

The line itself is a succession of artificial works and heavy earth-works, one of the cuttings involving as much as 10,500,000 cubic feet. Great care was taken in the thorough drainage of the hillside, but even with this precaution there was a landslide during the boring of one of the tunnels.

The aggregate length of the viaducts alone is more than one-eighth the entire line. Two of them are American-type trestle bridges, two others masonry, and the remainder Warren trusses on masonry piers and abutments.

The magnitude of these works is sufficient justification of the choice the company made between a short cable line and a long adhesion railway. The quicker the road gets over such a piece of country the better, as any increase in working expenses is far lower than would be the interest on the large extra outlay the building of the longer line (were it possible) would involve. Such as it is, the São Paulo Railway is certainly one of the very finest pieces of railway engineering in any part of the world.

The very first year the line was opened a 6 per cent. dividend was distributed, the Government continuing the 7 per cent. guarantee until 1873, at a total cost of £514,338. Between 1874 and 1890 the company's dividends kept above 8 per cent., and increased even to 15 per cent.

£927,041 were, consequently, refunded to the Government, whose share in exchange of the 7 per cent. guarantee was one-half the sums in excess of 8 per cent. dividends. In 1891 the São Paulo Company felt sufficient confidence in the future to do without the guarantee of interest, thereby ceasing to pay back to the Government. But the very next year, owing to the slump in the exchange, the dividends went down to 7 per cent., then to 6 per cent. the year after. Then came the general increase in the rates, followed by an increase in dividends, up to 14 per cent. in 1895.

But the company was obliged by its original contract to cut down its rates whenever 12 per cent. dividends were reached. Its efforts have tended to increase dividends as near to 12 per cent. as possible without passing that figure, and trouble with the Government has sometimes ensued, the latter contending improvements such as extra sidings, etc., should have been ascribed to capital expenditure and not to traffic expenses, as the company was doing. The ratio of expenses has kept under 40 per cent. from 1867 to 1888, with the exception of a single year. They have risen since and kept at about 60 per cent.

At the very outset the line was intended to reach Rio Claro; why the promoters did not continue it is a mystery, as the initial dividends were more brilliant than the most sanguine expectations could have anticipated.

But one extension has been added to the original line—the company purchased the Bragantina Railway, a 32-mile, metre-gauge line from Campo Limpo to Bragança. This

line had been granted a 90-year lease in 1873, and was opened ten years later with the usual privileges and guarantees. It may be that the Saó Paulo Railway Company purchased the line to secure the zone privilege belonging to it, since the line had been originally intended to run from Santos to the south of the State of Minas Geraes, striking the Sapucahy River where it became navigable, which would have created quite a new current of traffic down to Santos. But the starting point was altered and the 7 per cent. guarantee applicable but to £138,900, to Bragança, and to £39,700 for the section from Bragança to the frontier. The guarantee ran for only fifteen years, which cost the Government £207,060 in any case. Guaranteed capital expenditure had been increased by the bill of June 14, 1883, to £230,000.

The line is metre gauge, with 1 in 36 gradients, and curves of more than 366 feet radius.

No other line of any importance branches off the Santos and Jundiahy line except in Saó Paulo, as follows:

(1) A small line, the "Paulista Santos Railway," runs from Santos to Saó Vicente, 6 miles away; it is laid to the 4-foot 5 $\frac{35}{64}$ -inch gauge. The Sorocabara's projected extension down to Santos will pass through Saó Vincete as well;

(2) From Louveira, a station between Santos and Saó Paulo, a 12-mile line leads to Itatiba, in the north-east;

(3) Besides the important roads of the Central of Brazil Railway to Rio and of the Sorocabana Company to Botucatu and the west of the State, two small lines lead out of Saó Paulo.

It is only since the middle of 1910 that broad gauge trains of the Central of Brazil from Rio have run into the Saó Paulo Railway's "Luz" station in Saó Paulo. The Sorocabana's meter gauge station is close by.

The two small lines leading out of Saó Paulo are the Cantareira

Railway, owned by the State and worked in connection with the water supply of the town in the north, and the Santo Amaro line, in the south. This latter is a 10-mile line, just bought up by the Saó Paulo Light & Power Company, and started in 1883.

Finally, in Jundiahy, the Paulista's broad gauge line extends the Saó Paulo Railway far into the interior.

The many improvements the company has been effecting have considerably increased the capital, now reaching £6,738,802, or £79,119 per mile, for the Jundiahy line alone. This is as much as that of many a metropolitan railway and considerably more than any other company in Brazil.

The rolling stock includes 85 locomotives, 131 coaching stock and 2,873 goods wagons, all of British manufacture; these do not include the Bragantina line's rolling stock, to which the following data do not apply either.

The newer passenger locomotives are fine specimens of workmanship. They carry 206 pounds steam pressure, which is exceptionally high in Brazil. These are 69-ton, ten-wheel locomotives, 52.7 tons of which are available for adhesion. The cylinders are 25 inches diameter, with 20-inch piston stroke. The heating surface is 2,017 square feet, 1,865 of which are furnished by the tubes. The drivers are 64.6 inches in diameter.

The corresponding goods locomotives are consolidation (2-8-0) locomotives with 54-inch wheels. They have the same cylinders and a lower boiler pressure, 170 pounds, as against 206. They weigh 59 tons in working trim, 52.57 of which are adhesive.

A more interesting locomotive is the 1909 type of consolidation locomotive, provided with the Schmidt superheater. This engine is interesting on its own account, as all high-class, powerful locomotives are, but is also interesting owing to its superheater.



SUPERHEATED-STEAM LOCOMOTIVE BUILT FOR THE SAO PAULO RAILWAY BY THE NORTH BRITISH LOCOMOTIVE CO., LTD., GLASGOW

I have often heard it contended that superheating and compounding won't do in Brazil, because a good driver is required to handle them, and good drivers are available only on a limited number of roads. I do not think such is the case, and I expect Brazilian railways will derive as much benefit from the careful use of superheating as do those of European countries. Another interesting point is that, whereas the São Paulo Railway seeks higher efficiency in making use of the Schmidt superheater, the Central of Brazil is trying Vauclain's and Vaughan's, while several other companies, such as the Paulista and Mogyana Railways, are using (successfully) various systems of compounding.

The new engines I referred to were built at the Atlas works of the North British Locomotive Company to the specifications of Mr. Charles H. Fox, the São Paulo Railway's consulting engineer.

The degree of superheat is regulated automatically with the help of a servo-motor by a damper in the smokebox. The position of this damper can also be regulated by hand, from the driver's cab, where a mercury pyrometer's indications are transmitted to a temperature gauge.

The cylinders are outside the frames and $21\frac{1}{2}$ inches diameter by 26 inches stroke. They are provided with Schmidt piston valves. The valves and pistons are lubricated by Wakefield's mechanical lubricator—a good one were it provided with oil

gauges. The cylinders are provided with by-pass valves.

The engines have the Walschaert valve gear and Belpaire boilers and firebox.

The boiler is jacketed with asbestos, and carries 200 pounds working pressure.

The following are a few others of the principal specifications:

Truck wheels, 3 feet diameter; driving wheels, 4 feet 6 inches; rigid wheelbase, 16 feet 3 inches; total wheelbase, 24 feet; heating surfaces: firebox, 154 square feet; tubes, 1,410 square feet; superheater, 376 square feet; total, 1,940 square feet; grate area, 28.5 square feet; weight in working order, 75 tons 15 cwt.; adhesive weight in working order, 66 tons 6 cwt.; tender, 6 wheels; diameter of tender wheels, 3 feet 7 inches; tender wheelbase, 11 feet; tender water supply, 3,000 gallons; tender coal supply, 4 tons; tender weight in working order, 35 tons 3 cwt.

The average locomotive coal consumption is 47.8 pounds of coal per mile.

The whole of the rolling stock, both goods and passenger, is fitted with the automatic vacuum brake. The special locomotive-brake vans coupled onto the trains up and down the inclines have powerful emergency steam brakes besides, and grip brakes on the old pear-shape rails of the old planes.

The coaching stock comprises 36 first class coaches, 46 seconds, 9 composites and 30 vans.

The goods wagons comprise 103 animal wagons, 661 closed ones, 1,961 open and 53 flat wagons. There are besides 5 special wagons for inflammable matter, 50 ballast wagons and 40 special wagons.

The company owns a locomotive per mile of track, and slightly over 1 carriage and 34 wagons—a very high proportion indeed. Such an amount of rolling stock is necessary for coping with the very heavy traffic, as many as 132 trains being moved in one day. In 1908 it carried 1,535,568 passengers, making 32,244,380 passenger miles. The first class passenger travels 34, the second 18, the average being 21 miles.

The São Paulo Company runs five passenger trains daily between Santos and Jundiahy, besides a number of suburban trains out of São Paulo. A composite coach is coupled on to the goods trains, a great convenience to travelers, and hardly heavier to haul than an ordinary guard van.

The principal goods traffic is, of course, coffee exportation, some 75 per cent. of the production of Brazil passing over the São Paulo line. This reached 651,304 tons in 1908. There were besides 43,000 tons of sugar, as many of salt, and 23,000 head of cattle. The total is close upon 2,000,000 tons of goods (1,964,229), whose average carriage is 52 miles, or three-fifths of the length of the road. High earnings are the consequence; 87 per cent. are due to goods and 8.4 per cent. to passengers. The returns were £1,582,606 in 1908.

These high returns are due to the practical monopoly held by the com-

pany. A monopoly is not a good thing in itself, but it is sometimes the lesser of two evils. The railway had a guarantee of interest and still has a 39-mile guaranteed zone, half on either side of the track. Now these are two facts it is useless fighting against, because it is to the public's detriment to do so. You must wait until the privilege falls through and then see whether a competing line would be useful.

Several of these have been granted; some many years ago. Two may be built shortly: the Mogyana line, passing to the east of São Paulo and so down to the coast, and the Brazil Railway (Sorocabana section), to the west of São Paulo. But whereas the São Paulo Railway can continue working at a profit with considerably reduced rates, these new lines would have to remunerate a large capital, besides neither of them being as easy a one as the existing route. The principal argument in their favour is that practically all the railways of the State are laid to the meter gauge and that the São Paulo Railway is laid to the broad gauge. It is quite possible, however, that some arrangement may be come to whereby a meter line or a third rail might be laid along the São Paulo's track, or even allowing a meter gauge line to make use of the old inclines.

In any case, the São Paulo Railway is the only possible route from Santos to the capital of the State and to the Paulista Railway system beyond.

This is the reason the company can look the future in the face with such perfect confidence.

(To be continued.)

THE LABOUR CRISIS IN BRITISH SHIPBUILDING

By Benjamin Taylor

IT is easy to say that the present crisis in the British shipbuilding trade is the most serious incident in the history of that industry since the great strike and lockout of engineers which occurred in 1897 and lasting till the early part of 1898, for it is very much more. The engineering struggle did not concern marine engineering and shipbuilding alone, and as a matter of fact work in the shipyards went on all the time and the shipbuilding trade unions held aloof from the dispute. And the engineering war ended with a working agreement which marked such an advance in the economics of industry that it excited universal admiration and led to many imitations. The general principle of the conditions on which employers and men in the engineering industry settled their difference, which were fully dealt with in our columns at the time, was that in future there should be no stoppage of work, either by strike or lockout, whenever any dispute arises in any engine shop or in the whole industry, but that the points at issue shall be submitted to a series, if need be, or succession of conferences, terminating in a final conference between the central executive bodies of the Federation of Engineering Employers and the several engineering trade unions concerned in the agreement. With the details of that agreement and its subsequent amendment we need not deal further at present, but the broad fact remains that the engineers as a body have been loyal to the agreement and that if it has not preserved unbroken peace it has at all events prevented actual war during the past

twelve years. And this agreement was the basis of an arrangement with the shipyard workers the negotiations for which began soon after the engineering crisis and ended last year in the formulation of a still more comprehensive treaty with regard to shipyard labour alone.

Now it is the violating of this treaty which is the root-cause of the present lockout. That treaty was signed between eighteen (afterwards increased to nineteen) trade unions, of both black squad and white squad engaged in shipbuilding. It is more comprehensive than the engineering treaty, because it includes so many varieties of labour and because it embodies so many organizations in one common agreement. The fundamental principle of that agreement is that there shall be during disputes no stoppage or work by any trade union or by any members of any trade union, or through lockout by any employers belonging to the Federation of Shipbuilding Employers (which extends throughout the kingdom, with the exception of Belfast, the Thames and the smaller yards on the English Channel). It is, then, a national agreement and affects every branch of labour engaged in the construction, equipment and repair of iron ships. The alternative to stoppage of work in order to enforce a demand is immediate reference to a conference in the yard in which the dispute arises, then to a conference of local representatives of the Federation and of the trade unions, then to a central conference between the executive bodies of the Federation and the special trade union concerned in the particular dispute, and finally to a confer-

ence between the fully empowered representatives of the Federation and of all the trade unions who are parties to the treaty. This final conference was designed to prevent a strike in any district that would suspend shipbuilding there without the consent of all the labour concerned in shipbuilding in conflict with all the federated yards. In effect the design was that there should be no more local strikes, and the hope was that if a dispute were pressed to an extreme in any locality it must perforce lead to a complete national stoppage. By the terms of the treaty, the parties on both sides would exercise moderation and would not provoke a national calamity for purely local or individual ends. By making the issues so distinctly national it was intended to check and curtail sectional dissensions. And in this aim the representatives of the men were as eager and earnest as the employers.

The treaty was signed provisionally by the officials of the several trade unions concerned in the negotiations and afterwards confirmed by the vote of the men was by agreement taken in the aggregate of trade unions in their branches, but the entire membership of all the eighteen trade unions—not union by union—and the vote in the United Society of Boilermakers and Iron and Steel Shipbuilders was actually adverse to the agreement. But as the majority vote confirmed the treaty they were bound by it and accepted it. They have, therefore, no argument against its terms on the score that they voted against it as a whole. The officials of the society know and recognize this and have acted as far as they could up to the terms of the agreement, which remains a full and competent document. It is necessary to make this clear because there has been on behalf of the boilermakers some disposition to quibble on the subject. If they objected to any of its conditions their proper and only course was to negotiate for amendment—not to ig-

nore and violate a solemn agreement.

It is no secret in the trade, though it may not be known to outsiders, that the real stimulus to the promotion of the treaty was the conduct of the boilermakers themselves over a long term of years—in fact, as long as most of us can remember. By the collective term “boilermakers” is, of course, meant all the members of the Boilermakers’ Society, such as riveters, caulkers, platers, anglesmiths and other iron workers (not blacksmiths, who have two unions of their own now to be united) engaged in the construction and repair of iron and steel ships. It includes classes of workers who earn higher wages than probably any other class of manual workers in the world—except steel furnacemen. But while the shipyard ironworkers are men of brawny muscle, in the use of which they are dexterous, they are not of the intellectual dexterity of artisans like, say, machinists—engaged in the delicate work of the intricacies of engines. There is, indeed, in the labour world a subconscious belief that shipyard labour is overpaid in relation to the rewards obtainable for other classes of work depending mainly on the exercise of bone and muscle. We do not argue the question. The fact remains that these shipyard workers have attained to a high level of reward by the skillful organization and management of their trade union, which reached its highest point of strength when Mr. Robert Knight exercised practically undisputed sway over its destinies, and when the members would think no more of disobeying his orders or of disregarding his advice than they would of refusing an offered advance of pay. This is why the Boilermakers’ Society has been called the strongest trade union, or one of the strongest trade unions, in the world. And this is worth noticing just now because it has just exposed its weakness under present conditions.

A trade union without discipline

is not a union at all, but a travesty and a curse to everybody connected with it.

The practice of the boilermaker for years has been to endeavour to be a law unto themselves. They have projected demands of their own in individual shipyards and have been in the habit of throwing down their tools and walking out whenever it suited them to profess to take offense. It would be bad enough if such action affected only their own particular labour and suspended that alone, but neither riveters nor caulkers nor platers work alone. Each group links into the others and each workman in each group has assistants, apprentices, helpers and labourers depending on his individual work. Perhaps in a shipyard the real "solidarity" of labour is more apparent than elsewhere—certainly than in a congress of stump orators. But solidarity is precisely what your shipyard ironworker despises. He is as indifferent to the interests of his fellow-workers as he is to those of his employers, when he chooses to invent a grievance and to fancy the leisure and excitement of a strike. He spends his money, as a rule (though there are notable exceptions), as fast as he makes it, and when he is in full work he makes a great deal—anything between £5 and £10 per week. To men earning such wages a strike is a much less serious thing individually than it is and must be to men earning, say, 30 shillings to 40 shillings per week. The riveter, when he goes on a strike, is drawing, or has due to him, a good few pounds which will keep the wolf from the door—if it does not go to "the pub"—for a good while. And when it is done he can get credit from the shopkeepers, who know that he can pay up easily a week or two after re-starting. This is one reason—and perhaps the leading one—why the shipyard iron workers have become so addicted to what are called sectional strikes. A sectional strike may be either a strike of all the

workmen in a particular district or only some of the workmen in a particular yard. And the latter is the more vexatious because the more common and the more frequent. The sectional strike has been so long the curse of the shipbuilding trade that when the several associations of shipbuilding employers combined in one federation after the manner of the Engineering Employers, and after the federated engineering employers had demonstrated in 1898 the power of combination, it was recognized and foreseen that determined action would have to be taken to put an end to a senseless and ruinous system that was doing as much injury to the men as to the masters. Several times during the past ten years it has seemed probable that a shipyard lockout would be proclaimed in consequence of some foolish local strike about some matter that only required temperate discussion and arrangement, but the evil day was averted in the hope that the negotiations that had been begun toward a permanent basis of working would bring out a peaceful settlement of an old grievance.

The treaty was signed in the beginning of 1909 with the object of putting an end to sectional strikes. But it did not—not because its machinery was not well considered and in itself effective for every purpose in view, but because some of the men have simply ignored the treaty and its terms and contemptuously fell to their old resort of striking in odd lots whenever they thought proper.

Here it is necessary to explain that the nineteen trade unions signatory to the treaty have been, as general bodies, loyal to that bargain. This year the wage question has bulked largely in every branch of the shipbuilding trade. Advances amounting in round figures to 5 per cent. on current rates have been claimed in every department from all the trade unions, both associated and independent, in the shipyard and the engi-

neering trades. They may have been premature, inasmuch as the revival in shipbuilding was not universal, but it was so sufficiently marked with promise of further revival during the autumn as to induce the federated employers, after conferences, to agree to give the advances asked all round—for it is their contention that no change should be made in shipyard labour, either up or down, unless the conditions of the trade are such that the changes can be made general and applied to all branches of the industry. The boilermakers submitted to these negotiations as a body, and as a body fell in with the general arrangement. But all the same and all the time some of them were playing off their own bats and paying no attention at all to the terms of the treaty-playing for purely local and sectional demands.

The patience of the employers was great, but it was not inexhaustible, and those who are caustic about the madness of a lockout on one day's notice must be reminded that the trouble which is now being faced is of long standing, and that the failure of the treaty to end it, as hoped, and as the trade union officials promised, exhausted what stock of patience remained. The local disputes this year have been endless. Three times the riveters in the Partick yard of Messrs. D. & W. Henderson & Co. threw down their tools and left their work on demanding extra pay for special night work on ships under repair. This is noteworthy because it was the action of men at this very yard which produced the crisis of 1908, which led up to the agreement of 1909. Two months ago the Federation had to issue formal announcement that if the Partick men did not return to their work next day and submit their case to judgment in regular conference, a lockout would take place all over the kingdom in the following week. Yet the same men subsequently went out again and were one of the innumerable causes of the present lockout. The Federa-

tion have stated their case clearly enough.

"The threatened general stoppage of August arose out of a strike of caulkers and hole-borers. A vessel was lying in a public graving dock at Partick undergoing extensive repairs. A large number of plates had been removed, and while she was thus lying helpless the workmen held a meeting and refused to continue at work unless their demands for large increases on the rates of pay, which had been agreed to between the men's society and the employers' association, were instantly conceded. These changes on list rates it was out of the power of the firm to grant."

This strike was a distinct breach of the Shipyard National Agreement of 1909, made between the Employers' Federation and the 19 leading shipyard trade unions, which provides that under no circumstances must there be any stoppage or interruption of work on either side until any disputed question has been fully discussed in conference. The responsible unions, on being informed of the strike, instructed a resumption of work, "but it was not until a week had elapsed and the Employers' Federation had intimated a national lockout that work was re-started."

The immediate cause of the present crisis is due to two stoppages of work, one at the Walker Yard of Sir W. G. Armstrong Whitworth & Co., Ltd., and the other at the Partick graving dock of Messrs. D. & W. Henderson & Co., Ltd. In the former case certain questions have arisen, with respect to the riveting work of a new vessel which is being built on the new system of construction known as the "Isherwood" system. These questions were dealt with locally in accordance with the procedure laid down in the national agreement. "They came (say the employers) by way of appeal before the executive authorities of the Federation and of the unions in Central Conference on 25th August. There was a discussion

which lasted several hours. Ultimately an agreement was reached, which was reduced to writing and signed by the chairmen and leading officials of the Federation and of the Boilermakers' Society. The agreement arrived at was communicated to the workmen concerned. They held a meeting at the breakfast hour and decided to repudiate the arrangements which their own society had made a few days previously. A deputation waited upon the firm's management and intimated that unless the workmen's claim was conceded in full they declined to continue at work. Not only did those who were engaged on the particular work in question lay down their tools, but all the other riveters in the yard, though engaged on work with respect to which there was no question, also stopped." Here is not only breach of contract, but defiance of their own union's authority.

"The stoppage at Meadowside (Partick) graving dock was very similar to the one of a month previously. A ship was in dry dock undergoing repair. A large number of plates had been taken off and refitted to make ready for the riveters. The riveting squads sent to the job took out the necessary tools and went to the vessel, but declined to proceed unless certain demands for increased rates of pay greatly beyond the mutually agreed list were conceded to them. The men were asked to go on with the work at the usual rates and, in accordance with the National Agreement, to place their claim in the hands of their officials to be brought forward and discussed in the usual manner. They declined to proceed with the work until the demands were granted. The stoppage was immediately reported to the Executive Council of the Boilermakers' Society. The council replied that they had given instructions for a resumption of work. The society sent first one official delegate, then another, to secure a resumption of work, but with-

out avail in settling the question."

In this case no new question or new system was involved. Work was proceeding under the usual terms and conditions. The first intimation to the firm was the refusal to proceed with the work. No question had been raised or complaint made prior to this. Here also the union was defied.

Then in addition to the two cases referred to and which have been the immediate occasion of precipitating the crisis, the Federation have shown that there were about the same time three other stoppages of work, all being breaches of the National Agreement. Practically all the unions, they say, who are parties to the agreement have loyally observed it, but in the case of the Boilermakers' Society there have been numerous stoppages, notwithstanding repeated warnings of the grave state of affairs this would bring to pass. "On May 11th last, at a conference with the members of the Executive Council of the society, arising out of a serious stoppage in one of the large yards, this was strongly dwelt upon and intimation was given that these stoppages must cease or the Federation would take other measures to deal with them. Again on June 6th last, at a conference at which representatives from all the unions were present, attention was drawn to the serious fact that, despite the provision mutually agreed upon that there should be no stoppage of work, 35 strikes in breach of the agreement had been formally reported to the Employers' Federation, 27 of which were due to members of the Boilermakers' Society. Nearly 20 of these involved in each case a large number of workers. In addition to these stoppages, which were sufficiently serious to be formally reported, there had been numerous minor stoppages, minor in themselves, but in the aggregate occasioning great dislocation of work and loss. The unsatisfactoriness of this state of affairs:

was strongly commented upon, and the representatives of the workmen were urged to see to the careful observance of the agreement, as a continuance of the position disclosed was bound to lead to serious consequences and react on all trades engaged in shipbuilding."

On more than one occasion since this subject was referred to, and on August 16th, particular attention was drawn by the employers to the fact that, notwithstanding the promises of the unions and their efforts, there were during the previous four weeks 11 strikes, for 9 of which the members of the Boilermakers' Society were responsible. After that date the stoppages of work became more numerous—on an average one per day. "A condition of affairs (say the Federation) thus exists that cannot continue. The National Agreement has been collectively accepted by the societies on behalf of the men. It must also be respected and observed by the individual workmen or become practically a dead letter.

When the Executive Board of the Federation met at Carlisle four days after the stoppages work had not been resumed either on the Tyne or the Clyde, nor was there any indication of a resumption. The meeting unanimously resolved "that notices should be posted in all federated shipyards and ship repairing establishments, terminating the employment of all members of the Boilermakers' Society as at Saturday, 3rd September."

This meeting also resolved that "resumption of work will not be permitted unless and until satisfactory arrangements and assurances are agreed upon for the due observance in future of the Shipyard Agreement, and with regard to working conditions generally."

This, then, is the crucial point. The lockout has been proclaimed, not

because any section of the men asked higher wages than the agreed rates for some special or extra or new (as in the case of the Isherwood ships) work, but because they sought to enforce their demand in an irregular way. They broke the National Agreement by striking instead of referring their cases.

The lockout, then, is in consequence of a long series of breaches of contract and of violation of the National Agreement by one party to that agreement. The officials of the society deplore the cause and effect as much as anyone. But that is not enough. The federated shipbuilders see that it is perfectly hopeless to carry on their industry peacefully and profitably if the men repudiate their leaders and break their bargains. And the lockout will not be removed until arrangements are made for the future observance of contracts by all the members of the society.

This is a matter, of course, in which the members of the other trade union parties to the treaty are also deeply concerned. What assurances the employers may require, or what the society may be able to offer, we need not speculate here, as they will be known in due time, and there will be no peace until they are arranged. And if the ballot of the members of the Boilermakers' Society against the action of the Executive Council be confirmed by a ballot against the assurances to be offered to the Federation of Employers, then it is safe to say that the Boilermakers' Society will fall to pieces. That would be a pity in any case; but unless the working National Agreement be upheld by all the working class members party to it, then the principle of collective bargaining must cease to be a part of industrial policy. This is why the shipbuilding crisis is a crisis in the whole history of trade unionism.

PRACTICAL EDUCATION

By W. O. Webber

IT is believed that a good deal of the trouble with the established courses in industrial schools, and with the people who are talking about them, is that they do not properly make a distinction between the three separate phases of the proposition, into which it should be properly divided.

The first, manual training, is, beginning with the kindergartens, the elementary branch of training the hands, fingers, feet and eyes to do something with dexterity, a fineness of perception and touch, that are far in advance of the ordinary, and, like swimming, can never be forgotten; it almost always results in teaching the left hand to do things usually for the right, therefore making the pupil ambidextrous.

The second, industrial instruction, is the grammar school, where we should endeavor to teach how to make the most finished product out of the least material, with the least waste and in the least time. This should include regular trade schools, where the different handicrafts should have for its further aim to teach men and women to be foremen and superintendents.

We are spoiling lots of foremen and superintendents to-day by admitting them, as boys, to our technical high schools by too easy preliminary examinations, and the necessity of these technical high schools for the almighty dollar. No one should be admitted to such schools who has not the necessary preliminary mental education and the mental capacity necessary to fit them for professionals and experts. Seventy-five per cent. of the young men en-

tering these schools are not able, and have not the capacity for graduating therefrom. These men would make good superintendents and good foremen, but will never make good engineers.

The crying need is for schools to teach men and women to *be* foremen and superintendents, to teach them not only how to do a certain task, but how to do it the *best* way, and also how to handle a group of workmen so that they will do "team work," as a college football crank would say. We want professors of personality in such schools to teach men how to handle other men; we want professors of perception to teach men how to see clearly and how to remember what they have seen; professors of deduction to teach how to use what we have perceived with our senses; professors of shop strategy and shop tactics to teach how to take hold of certain work at the right time to make the results count big; in fact we want professors of humanity instead of homiletics. As a distinguished German visitor to this country once put it, "Your finest workshops are those in which you make your machines and your fabrics; our finest workshops are those in which we make our men."

If you will look in any technical or trade paper to-day you will find over 75 per cent. of the advertisements are "foremen wanted," and I know from personal experience that a *good* foreman is "of a price above rubies."

Besides this we want our highly-trained artisan, with his intelligence trained in the *art* and *technique* of manufacture; such training is not to

be obtained in a mill or workshop, in which each person is confined to a single process for too long a time and cannot watch progressive results which are the "crux of the game," so gets discouraged or blasé before he gets "light"; the factory teaches *how*, it does not teach *why*, to get the maximum results with the minimum effort. We want the *why* and the *how* taught together, so that the brain and the hand may work together to the best advantage. "The brain doth discipline the hand," no doubt, but the hand can often advise the brain when "persistence will be a virtue" and when "'twere folly to be wise."

If such a system of industrial instruction needed any further commendation, it might be found in the reports of our reformatories, which show that of all the men confined not more than 2 per cent. have any trade when committed, and all are set to work at a trade as a means of reformation. Would it not be better to compel the learning of a trade, *by law*, before the person has so offended against the laws of the community that it is necessary to lock him up in prison?

Another point which should be brought distinctly into prominence is the value of a handicraft and the good effect produced by manual training on the mental capacity. We are all willing to recognize that much homage is due the general handiness, as we call it, of the sailor man. The most illiterate and otherwise ignorant seaman is valuable to us in many ways, even on shore, because he has learned to be prompt—without questioning the reason or wherefore of the order given him. He has learned to control himself, to be quick-headed under moments of intense strain and excitement; and because of his training and his knowledge that he knows how to do some things superlatively well gives him a confidence in himself that is invaluable.

And third, we want technical education; such as the best of our tech-

nical schools are teaching to-day (only that the minor processes should all have been acquired before entering these technical schools), but in which less time should be spent on manual labor and subjects which should have been required in the grammar school and more time should be spent on a history of technical accomplishments and original research founded on broad principles.

For nearly a hundred years there has been a constantly growing misapprehension in the public mind that education meant training the mind in a purely pedagogic manner. The very word education, "from *e* out, and *ducere* to lead, to lead out, to lead forth, to bring up, as a child, *physically* or mentally, to prepare and fit for any calling or business, or for activity and *usefulness* in life," (Webster's *Una. Dict.*) states differently.

There is a great lack of practicality in the instruction of our public schools of to-day even in the branches which have always been well recognized as part of the ordinary school training.

This was brought out very clearly at the fifth spring meeting of the Association of Mathematical Teachers of New England, held at Boston recently, where the burden of the debate was that mathematics, in its various branches of arithmetic, algebra and geometry, was being taught in the schools of to-day purely as a science of culture rather than with a view to its practical application in the affairs of every-day life.

It was pointed out that the cultural value of the science of mathematics would be in no wise lessened by attention given to its practical application, while much of value would be gained in information and ability to apply abstract rules.

"If practical problems were given the pupil taken from every-day experience in the store, workshop or factory, which he was required to work out, confidence would be inspired in him and his ability to rea-

son in practical ways developed, so that he would not feel lost in attacking a problem in every-day life."

One of the speakers at this meeting said in part:

"Something has happened to grammar school arithmetic since I was a boy. The boys of my day were not at a loss, as are those of to-day, in making an adjustment between the theory of mathematics and its practical application. There was no such lamentable ignorance of facts or lack of power to make these common-sense adjustments with practical things.

"There is a surprising ignorance of the most elementary things in mathematics. About 75 per cent. of our boys always divide by the smaller of two numbers in any given problem, regardless of the relation of the numbers. I cannot understand why they are ignorant of the practical fundamentals.

"There is to-day also an almost criminal neglect in instruction of the common principles of arithmetic, and there is an immense amount of time squandered in setting down details of problems. There would be no difficulty in adjusting the ideas of bright minds with simple processes of arithmetic as taught in the technical schools, if as much stress was laid on the fundamental practice of arithmetic as there is in the fundamental theories.

"Under the present system of instruction the pupil lacks confidence in his ability to make practical application of mathematical principles. The question is 'How to establish this confidence.'

"It is perfectly logical that the colleges that set the pace for the high schools in their entrance requirements should put emphasis on the mechanical and industrial phases of mathematical instruction.

"A strong effort should be made to bring about some change in the instruction in high schools.

"The manual training schools and all those where special work is car-

ried on in applied sciences have a special mission in leading pupils to have confidence in working out the practical details of problems through demonstrating the construction of various articles.

"The fault in this respect is not altogether with the teachers, for American text books of recognized standing do not contain any concrete illustrations of practical value taken from the technical world. Mathematics as it is now taught is a mental discipline, but there is no reason why it should not have a practical value as well."

The necessity for any such discussion as quoted above simply emphasizes the fact that our system of public education has gone star-gazing or chasing rainbows, and that in so far as this is true the State is not doing its whole duty to the individual, because it is not giving *that form* of education which best qualifies the individual to discharge the duties of a citizen *in the sphere of life to which that individual is adapted by natural abilities*.

The writer believes that it was never intended by the Constitution of the United States that we should use a forced tax levy to give a select few such an education as is involved in our present high school curriculum. By a "select few" I mean that only a small proportion of those entering such a high school are capable of the sustained effort to obtain the full benefit from such an education, while the remainder, who inevitably fall down and are dropped or "plucked," as the saying is, bear the burden, or, rather, their parents and guardians do for them without reaping any benefit.

We must get down to a simpler system of educating the *average* boy and girl, cutting out the ologies and other abstract form, replacing them with manual training in the first instance, industrial instruction in the majority of cases and, possibly, technical education, at public expense, to those having the capacity for it.

Our high schools of to-day are easily comparable with the best colleges of one hundred years ago, and I think no one would have admitted for an instant, at that time, that it was proper to employ public funds to give a college education to those who were capable of undertaking or understandingly profiting by it, and, furthermore, I do not believe that it is any more proper to do this thing to-day than it was then. I believe that the *average* boy or girl, on receiving the higher branches of education, is as a result made more discontented, rather than happier, in the average conditions of life to which he is and has been accustomed, or to which he usually attains.

In India the Babu is an example of a good education thrown away, and shows to what extent the theoretical pedagogue carries his pet theories.

We should, therefore, use a more intelligent discrimination in our system (or lack of it) of public education. To use a very homely phrase, but a true one, our secondary or higher education, as now practiced in our high schools and applied to the *ordinary* boy and girl, is a pitiful illustration of the attempt to "make a silk purse out of a sow's ear."

The results are that to-day our society is overcrowded with second-class lawyers, doctors and other professional non-producing population. As a result we have entirely too many men endeavoring to live by their wits alone, thus degrading the so-called learned professions and producing the cheap doctor and shyster lawyer, while, strange as it may seem, the old millwright has practically gone out of existence and there are few carpenters to-day who know how to frame a truss properly.

Within a very short time the writer was called upon to investigate the trusses (?) supporting the roof of a public building, not a thousand miles from Boston, where he found two so-called trusses superimposed one upon the other, neither of

which was a complete truss, and therefore had no strength because of the lack of one member.

To quote somewhat at length from Mr. R. T. Crane, in the "Valve World," of May, 1908:

"When we put boys through the common grammar schools, giving them manual training throughout the grades with their regular studies, we are giving them on the educational side what is absolutely required for ordinary pursuits of livelihood and to make them good and useful citizens. I believe this is all the education that is required for ordinary business."

On the manual training side in the grammar school the boy may learn a great deal that will be exceedingly useful to him in the pursuit of a livelihood, whether he goes into a mechanical trade or not. He certainly should be well equipped to begin the practical pursuits of life. Manual training at this time of his life also tends to give him a liking and respect for mechanical pursuits.

Practically every one of the successful men of this country never had any more education than the grammar schools impart, and probably a great many of them did not get even half as much, with no manual training whatever. This makes it perfectly clear to me that a grammar school education is all that is required for ordinary business pursuits. And a boy so equipped to-day, with such manual training as now is given in some of the grammar grades, is even better prepared for the battle of life than were the men who made this country what it is.

I contend that when we go beyond this we begin to weaken or tear down the foundation we have been building in the common grammar school. When we offer education higher than this, we practically say to the boys: "If you will come to this higher school we will qualify you for something better than mechanical pursuits and the ordinary

drudgery of life," and thus teach disrespect for the person who has had nothing but a grammar school education. We lead the boy to believe that by going through the high school he will be able to make a living much easier and more pleasantly than if he quit at the grammar school.

Just here I might say, as an English writer has said on this subject: "Here is where the curse of education begins." And I may add that the curse continues all the way along the higher educational institutions right up to Harvard and the like.

There probably has never been a more comprehensive and complete series of articles on the subject of the faults of imposing higher education upon the average youth than was contained in a paper by Professor Milton P. Higgins, of Worcester, Mass., at the New York meeting in December, 1899, of the American Society of Mechanical Engineers, and which forms paper No. 850 of Volume 21 of the Transactions of said society, and the discussion upon this paper, which was contributed by Rear Admiral George W. Melville, late Engineer in Chief of the United States Navy; Professor Frederick R. Hutton, Dean of the Faculty of Columbia University, New York; Professor R. H. Thurston, late director of Sibley College of Cornell University, and almost all of the heads of departments of this latter college, and, in fact, all of the leading professors of mechanical engineering of the leading colleges and technical schools of the United States.

I would call attention to the small percentage of pupils who graduated from the technical institutes, but this small percentage of 25 is a magnificent showing when we consider that, by the report of the Commissioner of Education for 1896-7, we find that of 16,255,093 pupils enrolled in the schools of the country that only 165,000 students appeared in the colleges and universities of the same period. This means that only 1 per

cent. can afford to have the benefit of a higher education.

From the educational reports of 1897-8, 80 per cent. of the pupils dropped out before they reached the high school, and 97½ per cent. before graduation from the high school. It is possible that a large proportion of this per cent. which drop out do so because of the necessity of their earning some sort of wage in order to contribute to the family support, but the fact that our State laws largely forbid the employment of minors under fourteen years of age would seem to show that some other reason was the principal cause of their defection at those ages earlier than that which allows of their lawful employment. These ages also show that the last two years of the grammar school furnishes the rock on which they come to grief.

Professor Higgins advocates half-time schools, combining with a grammar school a first-class mechanical trade school, where a boy can have an opportunity to learn one of half a dozen good trades without being deprived of a good common school education, and upon which he can build a higher education if capacity and circumstances permit. His idea was that such mechanical plants should be commercially productive machine shops, nearly self-sustaining and having the benefit of an endowment to meet the deficiencies, or a regular business corporation, working for a profit.

The writer does not believe that this is the solution of the question, but agrees with Admiral Melville that, as the State does not hesitate to provide the ways and means for the higher education of its youth, the State should supply, wherever possible, properly and thoroughly-equipped school shops for its coming mechanics. Such shops should be equipped upon the same general lines as the best shops engaged in the production of first class machinery, and they should manufacture some articles which can be readily marketed.

preferably school fixtures and supplies, and educational apparatus.

To my mind there should be no more objection from trade unions to this entering into of competitive manufacture than there is now to the product of our State prisons and reformatories. In fact, as the product would be the means of equipping public schools with the needed furniture and apparatus more cheaply, and as the people at large who pay the taxes would all benefit in this resulting cheapness, it seems to me like a case of public welfare, in opposing which the trade unions would be simply biting off their noses.

Of course, the teaching force of such schools would have to be practical mechanics of the highest type, selected with special regard to their skill and to their fitness to aid and instruct the pupils in doing all kinds of shop work by the best, most effective and economical methods. The old-time pedagogue will have to change and subordinate some of his isms and ologies to a more comprehensive, practical horse sense in education, for the reason that the half time which the student was not in the shop schools should be spent in a thorough acquisition of the three "R's," spelling, English composition, geography, history, natural history and a knowledge of business methods.

A certain grade of selection should be maintained in the class of pupils best fitted to undertake certain branches of work; the brighter boys, of course, would make machinists, then pattern makers, carpenters, blacksmiths, moulders, brick masons, plasterers. In fact, there would be almost a natural selection, supplemented, of course, by the observation of the trained instructors. The brighter boy, on graduation from this school, would be better fitted to go into the technical school and on to the profession of engineer.

The educational ideas in the school shop would have to be very much

reversed from usual practice, much that is dear to the mathematician and physicist would have to be discarded; the work would have to be arranged so that each student could go as rapidly or as slowly as his ability allowed. Experimental apparatus should be installed, so that natural laws may be illustrated, but not necessarily proved, as it is the intelligent use of these laws and not their proof which is desired. Models and actual machines should be used for illustrations. All problems should be worked in the language of the shop, although made to include many principles of mechanics, strength of materials, etc.

Text books would be very sparingly used, for two reasons—the first that the literature for such instruction is yet to be written, and secondly, because it is designed to make the shop school as much a relief from the actual school as is possible. The bulk of the material would be in the form of separate instruction sheets, given out one at a time.

A large element of this grade of work would be mechanical drawing, omitting entirely theoretical drawing or skill in making particularly fine drawings, but requiring the production of a working sketch that is readable by another student.

A law, known as the "Morrill Land Grant Act," passed by Congress in 1862, provided for the establishment of just such schools, which, without excluding other scientific and classical studies and including military tactics, were to teach such branches of learning as are related to "Agriculture and the mechanical arts, in such manner as the Legislature of the State may prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." If the Congress of the United States could pass such an act forty-five years ago, it surely is time for other Legislatures to do as much.

THE PROPULSION OF SHIPS

By John Batey

CALCULATING the power to drive any ship at a given speed on a known displacement is not easy; neither is it certain, when the calculation has been completed, that the result will be comparable with the figures.

The calculation is complicated by problems which throw doubt on the accepted formula; therefore, to a large extent, previous experience is adopted as a rule rather than a correct theory.

The effect of dimension on the result, such as length, breadth, depth, and even shape, have all been experimented with, and the data derived from such tests have an important value.

To Colonel Rota, of the Italian Navy, great credit is due for information given, which he obtained by direct experiment in the Italian testing tank, and by observation of the effects on the value of the propulsive power by alteration of one dimension at a time, he has furnished data of especial value, which forms the groundwork of the present article.

Five definite rules have been adopted as a result of the observed effects, which are as follows:

1st.—That increase or decrease of breadth or depth resulted in a corresponding alteration in the power for one speed.

2d.—That given one displacement, the power varied most as the breadth was altered; or when the displacement was varied, it varied most by alteration of breadth.

3d.—With one displacement the skin resistance remained constant, no matter what the breadth or depth.

4th.—Increasing the length reduced wave resistance, but skin friction in-

creased rapidly with increased length.

5th.—That alteration of length, whether by increase or decrease, whilst altering displacement did not materially affect the power factor as a proportion within reasonable, practical limits, as ascertained by the resulting speed.

Three deductions arise out of the rules—i. e., the

1st.—Proves the effect of general variation;

2d.—Shows the effect of altering one dimension;

3d.—Shows that skin friction is directly proportionate to displacement, and that different shapes, giving different superficies, neither add to nor take away skin resistance.

The last is important; it narrows the issue and brings in the rule that skin resistance is measurable by displacement.

To illustrate this, a given displacement is referred to maximum length and depth and minimum width for one case, and to minimum length and depth with maximum breadth for the other. In both cases the total skin resistance is the same, though the wetted superficies are widely different.

Take as an example a rectangular tank of a given displacement—427 feet length, 9 feet depth and 3 feet width; the total superficies equal 706 square feet.

Assuming that displacement just keeps the surface of the tank above water level, it matters not how the tank is placed in the water; one surface is not wetted. Placed in the water with the 3-foot face upward, the wetted superficies equal $(702 \text{ minus } 81) = 621$ square feet.

With the 9-foot surface upward the wetted surface is only 459 square

feet, whilst sunk-end down, only 27 square feet of surface is unwetted, and the wetted surface equals 675 square feet.

The ratio is fully 1.4, yet the skin friction is above (x) for the three positions when the tank is pulled through the water.

Whilst this is true, other resistances vary according to the position in which the tank is floating.

For No. 1, the head resistance is due to an exposed surface of 27 square feet.

For No. 2, the surface is the same; whereas for No. 3 the surface, with the 9-foot face forward, equal 243 square feet, or with the 3-foot surface forward, 81 square feet.

Taking the last as an example, whether the tank is placed end down with the 3-foot face forward or laid flat with the 3-foot face forward, the actual area of surface exposed is the same; yet the first will offer less head resistance than the second, by reference to the deduction derived from experiment.

As both areas are equal, the actual weight of water to be moved is likewise equal; therefore, it cannot be weight or pressure effect; it must be frictional.

If this is true then shape does add to frictional resistance, and the rule that skin resistance is directly as the displacement requires qualifying.

It must be stated that skin friction is totally different to any frictional resistance set up by head thrust. The first is caused by water sliding upon, or past, material; and the other is caused by water sliding across a surface when subjected to considerable pressure, which appears to assume a condition that pressure has an influence upon the value of frictional resistance.

It is a fair assertion to make that, unless water was subjected to frictional resistance, head resistance could not exist.

Head does offer resistance to a ship when driven through the water, and displacement of water at the bow

is of greater quantity than the water replaced at the stern, and the resulting effect is as if the ship was forced up an incline, which condition is recognized, and ship resistance is often referred to the condition.

While depth of vessel only directly affects the power result in exact proportion to the displacement whilst the power for double breadth demands more than double the displacement, is the point of importance.

Wave resistance must increase the head of water at the forward part of the vessel, and skin resistance is instrumental in reducing the head, or water level, at the stern, and the two effects combined measure out the total resistance and the effect is as already given.

It requires little argument to prove that a flat surface will carry with it more water than a rounded one and a conical projection will carry none, assuming that there is no frictional resistance; but there is, and even the conical projection will take water ahead with it.

If there was no frictional resistance even the flat surface would not carry any water ahead with it; therefore, the cause is frictional, but it is a conditional cause.

Altering the depth of the attacking surface simply adds to the resistance in proportion to the depth, but adding to the breadth brings in a different set of conditions.

Doubling the breadth doubles the time during which the water takes to get away from the centre, which is the point of attack; therefore, the quantity of water retained in frictional contact for the double width is twice that of the other. Thus it is obvious that time multiplied by quantity increases the resistance in proportion to the square of the breadth, which is what practice proves.

Here is revealed the reason why increase of width adds more than a proportionate resistance. Increasing the depth increase all resistances pro-

portionately, whereas increasing the breadth adds very little to skin-resisting surface for the extra displacement; but the head resistance increases as the square of the breadth.

Under the conditions examined the power for propulsion may be calculated on the assumption that the power is proportionate to the length, and equally so in regard to depth; but it is as the square of the breadth. This may be reduced by shape of bow, and according to its fineness the resistance decreases.

Whatever the quantity of water moved ahead at the speed at which the vessel is moving, the same quantity is referred to the fined down bow; but the speed imparted to the water is considerably reduced, therefore less power is required to overcome the resistance.

Referring the bow to a triangle, then half the base is one component and the perpendicular, or length, is the other.

Whatever the proportion of base to vertical, the head resistance is as the base. Suppose the base is 1 and the perpendicular 3, then the resistance referred to the square of the breadth is only one-third, which is the true head resistance.

In general practice the bow length is referred to a given proportion to the length, and the stern to a less proportion. The practice seems to be contrary to what should be. The less fine stern, as a proportion, displaces more water than the bow, whereas the condition seems unreasonable. If the bow displaced more than the stern for a given length, and the difference was made just that by reference to the total resistance referred to a body of water, then the ship would be propelled on an even keel instead of up an incline, and power would be saved, because displacement would equal replacement and one factor of resistance would be destroyed.

Going one step further; if replacement was made faster than the water was displaced, then considerable cavitation at the stern would be avoided

and more power would be saved.

These are points the article indicates, and they are based upon scientific principles and natural law.

Probably the result would be that skin friction would also be reduced, and this would save power also.

A porpoise is built on such lines, and the fish can beat the fastest ship easily. Nature supplies a lesson, if we can profit by it.

It appears as if the future of propulsive effort, looked at on such lines, held hopes that, realized, would mark a distinct departure in ship propulsion.

The case is not nearly completed, and could not be in one short article; yet the member on which really depends the value of the propulsive power—the propeller—must be referred to, because it probably wastes more power than it has ever been credited with, though it is saddled with enormous losses, which are, unfortunately, looked upon as contingent to the conditions.

Instead of which it may be because little knowledge exists of any real value as to its true function, or even its actual action.

An object lesson was presented by the Italian man-of-war, the *Vittoria Emmanuele*, whether intentionally or by one of those fortuitous circumstances that occasionally arise and are called problems; it matters not how it arose, the fact is pertinent that ship attained a speed on her displacement on a lower power effort than any vessel has been known to work under before.

The reasons why she did so are worth analyzing, and if the effect is traced back to the true cause another element for saving power and increasing the value of propulsive effort has been revealed.

Probably at some future date the theory and practice of propulsion will so closely approach each other that maximum weights will be carried at maximum speeds by the expenditure of a minimum power.

LESSONS FROM THE WELLMAN EXPEDITION

By Henry Harrison Suplee

THE recent attempt of Mr. Walter Wellman and his associates to cross the Atlantic in a dirigible balloon, while unsuccessful in its main object, may be considered to have contributed in no small degree to the ultimate solution of this great problem. No great undertaking of this kind has been successful at the first trial, and often many successive attempts have been necessary before sufficient data of a reliable kind were obtained to be of real and practical value.

Measured by previous efforts of a similar kind, the abortive attempt of Mr. Wellman may well be accepted as a contribution toward the next expedition, much as the earlier trials to lay a transatlantic cable were most valuable lessons leading to the ultimate and successful result. It may be desirable to examine some of the features obtained by this brave and hazardous experiment, and try to perceive the germs of future success which are embodied within them.

In the first place, it has been demonstrated beyond doubt, both by Wellman and by Zeppelin, that a great dirigible is capable of sustaining itself and its burden in the air for a period of more than three days, while traveling a distance of more than a thousand miles. This in itself is a long step forward in the solution of the question of the crossing of the Atlantic.

In the second place, the Wellman experiment has shown the undesirability of maintaining any contact, through a trailer or equilibrator, with the surface of the water, such an attachment acting both as a transmitter of wave shocks and as a retarding brake.

In the third place, the feeble influence of engines and propellers, as thus far applied, in comparison with the power of the wind acting upon

the balloon, has demonstrated the necessity for greater engine power and propeller efficiency, if the term *dirigible* is to be considered to mean anything under conditions encountered in the Atlantic crossing.

It has always been considered that any attempt to cross the Atlantic through the air must be effected largely by the aid of the wind, just as the first vessels to cross by steam power upon the surface of the water were propelled by the combination of sail and steam. The immediate usefulness of the motors, therefore, must be considered to lie in their ability to direct the air-ship into the currents of wind available for its guidance in the desired direction, rather than for its full propulsion.

An observance of the prevailing winds in crossing the North Atlantic will show that, while no general rule can be held to apply, there are certain probabilities which may be taken into account. While there is a general easterly and westerly trend to the wind, this sweep is liable to be crossed by a strong current from the north, after the Banks have been passed in the eastbound crossing. This northerly current made itself felt so strongly in the case of the Wellman expedition that the machine was carried far to the south, and failure of the undertaking naturally followed. It was the function of the motors and propellers to contend with just such a current and to carry the air-ship across this diverting wind and bring it again into the west wind which was acting beyond in the precise direction desired. To do this, however, demanded far more power than was available on the *America*, and, in the absence of sufficient power, the failure of the expedition became certain. The first lesson to be learned from this latest effort, therefore, is found

in the fact that the power is required for emergencies, rather than for steady action, and that capacity for a vigorous spurt of moderately brief duration is essential to success.

The fact that the Wellman balloon remained in the air for a period of about one-third of the total time probably required demonstrates that much progress has been made in the construction of the gas bag and in the material of which it is made. Mr. Wellman, however, is reported to have stated that they had lost about 40 per cent. of the gas during that time, and that it is doubtful if they could have kept in the air longer than another day. It has thus been determined, as a result of the Wellman undertaking, that further improvements in balloon fabrics must be made if the Atlantic crossing is to be accomplished within the time limits at present in sight.

Another feature, and one which has already been met by aeronauts with the ordinary drifting balloons, is the influence of temperature changes upon the volume of the gas, and hence upon the sustaining power of the gas bag. The recent balloon trips in various countries have emphasized the chilling influences, and consequent contraction of the gas, when passing over bodies of water, and it must be expected that similar changes will be experienced in passing through the air currents of varying temperatures encountered in the ocean crossing.

Some effective method of protection against sudden temperature changes will doubtless be devised, either in the form of a protective jacket, or in some method of supplying warmth to meet the chilling action of the cooler atmospheric strata.

Any further attempts to make the Atlantic crossing may therefore profit by the experiences of the Wellman expedition in some vital elements.

Greater power will have to be provided, together with motors of full reliability and high fuel economy. Some improvements in gas-bag construction, reducing the losses of gas through osmotic action, are most de-

sirable, if not essential, since the machine must be capable of remaining in the air for at least a week or ten days.

Something must be devised to replace the equilibrator, if, indeed, any device of this sort is desirable at all. Possibly it will be found better to attempt navigation wholly in the upper strata of the atmosphere, and abandon any effort to maintain connection with the surface of the water.

A most important matter, and one which can be developed only in the course of time, is a fuller knowledge of atmospheric conditions along the route to be traversed. At the present time the meteorological reports and predictions immediately available from the United States Weather Bureau extend only about as far as the Grand Banks, supplemented by disconnected data obtained by radio-telegrams from vessels at sea. Before transatlantic aerial navigation is to become an assured fact, it will be necessary for the meteorological probabilities along the entire route to be recorded, a result which can be effected only by close co-operation between official services on both sides of the ocean, combined with systematic reports from all vessels along the route. This will doubtless come, but the time of its accomplishment cannot be predicted or even assumed.

In this connection it is interesting to note that the proposed attempt of Mr. Joseph Brucker, to make the crossing in a westerly direction, starting from the Canary Islands, and having the West Indies for its destination, is receiving serious consideration. This plan, which includes the utilization of the edge of the trade winds, has been under consideration longer than the Wellman project, and it contains certain elements of probability which deserve examination. For success, however, one of the features above mentioned is essential—the assurance of a gas bag which will hold its contents against leakage and other losses for a longer period than has been shown practicable as yet with any material commercially available.

HANDLING GRAVEL MECHANICALLY

By H. H. Kress

WITHIN the last few years rapid strides have been made in the reconstruction of the highways, as well as the labour-saving devices for the handling of the materials that go to improve old roadways and build new roads.

The automobile industry has acted as a stimulus to build good roads, and where gravel is found in abundance it finds its way for top surfacing macadam roads.

Along the Pacific Coast the gravel is obtained from large pits on the shore of Puget Sound, about 30 miles by water from Seattle. The barges are loaded up and towed by tugs and delivered alongside the pier in Seattle.

A unique system was recently discovered in that city for unloading the gravel from the barges to elevated storage bunkers, from which the gravel is loaded on wagons by gravity, as well as to the railroad cars for transporting gravel to other points.

The elevated bunkers are located on the water front, being constructed on pile footings at the head of a narrow slip.

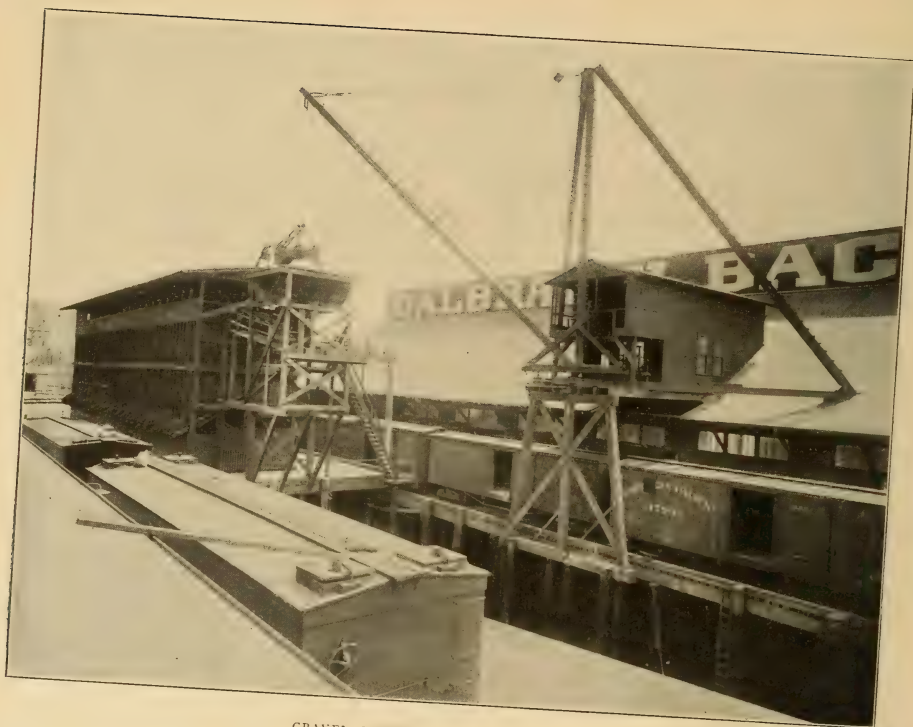
The illustration shows a recent view of these bunkers. Along both sides of this narrow neck of land are located large warehouses on wharves extending out to the harbour line. Between each wharf and the slip is a pile trestle carrying a railroad track, and these tracks connect at the shore end of the slip with the main line of the Great Northern and Northern Pacific Railroads. The gravel barges arrive alongside the pier and are unloaded with the use of a clamshell bucket swung from a stiff-leg derrick mounted on a trestle over one of the railroad tracks, and the gravel discharging into a Jeffrey

receiving hopper elevated at the end of the bunkers, or directly to cars on either track. Nearly all of the gravel, however, is delivered to the storage bunkers for local distribution in wagons.

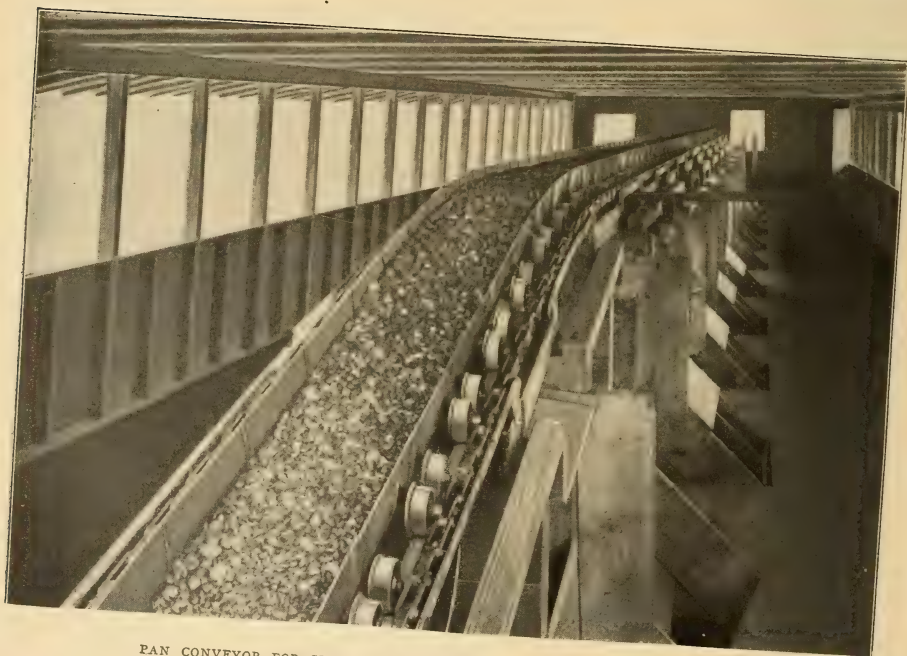
The derrick is operated by a double-drum hoist geared to a single-phase, alternating-current, variable-speed, 60 horse-power motor.

The bunkers are 20 by 120 feet, and provide a storage capacity of over 1,000 cubic yards. They are divided into twenty-four separate bins, enabling the various sizes of gravel to be handled through them independently. The gravel passes from the receiving hopper through a distributing plate feeder, which is so constructed as to also handle sand to a Jeffrey steel drop pan conveyor, which extends over the entire length of the bin on the longitudinal centre line of the latter. A roof is provided which covers the bins and conveyor line.

The conveyor line is 130 feet between centres and traveling at 70 feet per minute geared to a single-phase, alternating-current, continuous-speed motor. Each pan section of the conveyor is 18 feet wide, 24 inches long and 6 inches high, carried on two axles supported by two pairs of flanged wheels placed at the ends of every pan and traveling on a pair of rails on a frame spanning the bins. Only one of the axles extends to the chain, allowing the pan to pivot freely between the two strands of chains. The rails are in sections, hinged over each bin, so that any section may swing out of the way. This conveyor is so designed that when each pan reaches a delivery point where a section of trackage has been taken out, the rear end of the pan automatically drops



GRAVEL BUNKERS AT SEATTLE



PAN CONVEYOR FOR GRAVEL. JEFFREY MFG. CO., COLUMBUS, OHIO

down and the load is discharged into the bin below. As the conveyor proceeds, the pan returns; the separate pieces of track swing back, in no way interfering with the movement of the conveyor.

The floors of the bins are sloped to a row of outlet chutes along both sides. A roadway is built around the bunkers at the level of the street in front of the slip, in order that wagons approaching and leaving do not interfere. The chutes are set to deliver into the wagons, and are each controlled by a gate operated from the latter.

Barges loaded with gravel are delivered to the plant at frequent intervals, according to the demands of the market. The gravel is unloaded from them at the rate of 100 tons per hour, and a supply drawn from the bunkers as may be required. Under normal conditions the derrick will deliver from the barges to the elevated hopper at a rate of 60 cubic yards per hour.

The entire conveying system was designed to handle the gravel as rapidly as it flows from the hopper, its rated capacity being 80 cubic yards per hour.

RAPID GROWTH IN THE USE OF AERIAL TRAMWAYS

By William Hewitt

THE adaptability and economy of aerial tramways for transportation of ore in mountainous localities are well exemplified in the line recently built by the Trenton Iron Company, of Trenton, N. J., for the Utah Consolidated Mining Company, at Bingham Canyon, Utah, which is 28,800 feet long, and with a fall between the terminal stations of 1,325 feet. This line, which is designed for a capacity of 100 tons per hour when running up to full capacity, is estimated to develop about 74 horsepower, with no back freight on the line. As the power developed, however, may vary considerably, according to the conditions under which they happen to be operating, and at times when they carry back freight, for instance, power may be required, electric motors are provided, operating in such a way that they serve as controllers or motors, as the conditions may demand.

The line is divided into three sections, the first section, 4,600 feet long, extending from the loading terminal to the summit of the mountain, 1,455 feet above the loading terminal. The second section, which extends from the mountain summit to an intermediate station 1,500 feet below, is 3,760 feet long, while the balance of the distance is covered by the third section and has a fall of 1,219 feet.

The track cables used are $1\frac{1}{2}$ inches diameter on the loaded side and 1 inch diameter on the empty side, and are of the patent locked-coil construction made by the Trenton Iron Company. The traction rope used is $1\frac{1}{16}$ inches diameter, of Seale construction, Lang lay,

these cables and traction ropes being carried on eighty-two supports and one rail structure in the third section about 45 feet long, where the line conforms to an abrupt downward grade, the cables at this point being overlaid with rails such as used at the terminals and intermediate stations, in order to save them from undue wear. Besides this, there are six tension stations, where the cables are parted and either anchored or weighted, as the case may be.



AERIAL TRAMWAY AT BINGHAM CANYON, UTAH



TRENTON AERIAL TRAMWAY. UTAH CONSOLIDATED MINING COMPANY, BINGHAM CANYON, UTAH

From tension station No. 2 to the summit the line makes a clear span of about 1,100 feet.

The two motors used to operate the line are located, one at the station on the mountain summit and the other at the intermediate station joining sections 2 and 3. The station on the mountain summit is really a connecting station joining stations 1 and 2, which, when running to full capacity of 100 tons per hour, require from 20 to 26 horse-power. The third section is practically an independent line, developing about 100 horse-power when running at full capacity, and the motor at the intermediate station constituting the upper terminal of the third section is so designed that, when running at normal speed, it acts as a generator, and, therefore, supplies all the power necessary for running sections 1 and 2, with an excess that is absorbed by brakes. The arrangement, therefore,

meets all conditions, the motors serving to supply such power as may be required in starting the line, especially after it may have been stripped of the carriers, and also utilizing the large amount of power developed after the line is fully loaded and running up to full capacity.

Two hundred and twenty-two carriers are used in all, 210 on the line and 12 at the stations, with 8 cubic feet steel buckets and patent automatic underhung grips, and these carriers are moved at a speed of 600 feet per minute.

The Trenton Iron Company is engaged in the building of a line for the Nevada Mining, Reduction & Power Company, at Dayton, Nev., 20,580 feet long, with a fall in this length of 920 feet, which will be used for transporting ore, this line being designed for a capacity of 25 tons hourly, and also a number of smaller lines.

THE SCIENCE OF WATERPROOFING

SECOND ARTICLE—EFFECTIVE EXTERIOR WATERPROOFING

By Edward M. Caffall

THE treatment of the exterior of a building to render it permanently and effectively waterproof demands not only the material and the process but the knowledge of the characteristics of the object to be treated on the part of the operator as well. A stone long exposed to the weather cannot be waterproofed in the same manner as a stone newly taken from the quarry, though there is a principle underlying all operations which is the same in every case. This may be illustrated by the fact that blue stone cutters cannot cut brown stone, nor can brown stone cutters work up granite—that is, to the best advantage. Of course, all stone cutters can cut all kinds of stone. This is the reason for the existence of the different labour unions of stone cutters. The same principle holds good for the waterproofing. Even on the front of a building different methods must be adopted, according to the location of the stone.

Hence, to effectively waterproof a building or a monument, science, experience and skill of the highest degree are demanded.

It will be seen that these remarks do not apply to the superficial washes, or mixtures of so-called "waterproofing," so widely advertised. None of them claim to be permanent, and, therefore, none of them are effective. There is only one permanent, effective waterproofing process, and that is known as the "Caffall process for waterproofing."

The clearest evidence that can be brought to show the truth of the above statements has been recently

furnished by the London, England, authorities.

The obelisk on the Thames Embankment (Cleopatra's Needle) has been treated every year for thirty-one years with a "preservative waterproofing compound" of the same nature as the above-mentioned widely advertised coatings. This year the condition of the "Needle" has become so alarming that they are seriously considering removing it at once to the interior of the British Museum, to keep company with the two Egyptian obelisks already there.

This unfortunate stone, notwithstanding its frequent annual protective "waterproof" coatings, presents the appearance of a dilapidated factory chimney. Vastly different is the condition of its sister obelisk in Central Park, New York. Though standing for thirty years in the extremely severe New York climate, there is no anxiety or alarm in the minds of its custodians. It costs absolutely nothing to maintain its clean, sound and beautiful appearance, and this is a puzzle to Londoners.

Why should there be such a striking difference in the condition of these two obelisks?

The reason is known to every American.

In 1885 Robert M. Caffall was engaged by the Department of Parks to apply the "Caffall Process for Waterproofing" to the New York obelisk. For the succeeding twenty-five years that stone has towered aloft on its eminence in the Park, defying the elements which attack it on all sides. Frost, rain, the sun,

gases, smoke and the wind strive vainly to affect the stone, in spite of the fact that the Obelisk had been left unprotected for four years after its erection in the Park and seriously damaged thereby.

Moreover, the protection afforded by the process is still effective. There is no known reason why it should change during the next twenty-five years. Even lightning cannot strike the shaft, owing to the non-conductive properties of the materials used.

Here, then, is an example of effective, permanent exterior waterproofing contrasted with the feeble, ephemeral "waterproofing coatings" which have been thus demonstrated to do absolutely more harm than good. Money is worse than wasted in their purchase and use.

The reader must bear in mind the difference between underground waterproofing (the pitch, asphalt and tar-paper system) and the exterior, above-ground wall waterproofing. They are not the same, though in principle akin.

Of more recent date, and illustrating the opening remarks, is the treatment of the Italian fountain in the New York Zoological Park (Borough of the Bronx). This beautiful object stood for eight years between the primate house and the site of the new administration buildings. Last year it was determined to remove it, at great expense, to the centre of the Concourse. While being erected in its new location it was treated with the Caffall process for waterproofing. Those who remember it in its old location will appreciate now the benefit conferred on the stone by its treatment. Some of the stones were completely shattered by dampness and frost.

Hundreds of buildings of every kind of building material and ranging from the tenement to the mansion have been treated by this process and rendered permanently dry and sanitary. Some date back to 1879. All are still good and sound.

It is a strange feature of our aver-



THE OBELISK IN CENTRAL PARK. PROTECTED BY THE
CAFFALL PROCESS

age modern construction that property owners and architects seldom make provision for the protection of stonework or brickwork from the weather when designing a building, notwithstanding the evidences on all sides of the damage wrought by the weather in a short space of time (even ten years). All iron and woodwork is given at least three coats of paint, and thereafter every three or four years this iron or wood has its protective coating renewed, while stone and brick are neglected until the water begins to penetrate into the building, and even then is tolerated as a necessary evil.

BOOK NEWS

Machine Design

Self-Taught Mechanical Drawing and Elementary Machine Design. By F. L. Sylvester, M.E., with additions by Erik Oberg. Illustrated. pp. 330. Price \$2.00. New York: The Norman W. Henley Publishing Co.

A very convenient and instructive work, devoted mainly to the practical work of mechanical drawing, but containing also such information about mechanical computations and the simpler problems of machine design as to render it especially well adapted to the student or mechanic who is obliged to depend upon his books and himself to secure his technical education. For such students this book can be recommended, enabling, as it does, an excellent knowledge to be obtained of the fundamental principles upon which machinery is designed and working drawings made.

Pocket Book

The Mechanical Engineers' Pocket Book. A Reference Book of Rules, Tables, Data and Formulae for the Use of Engineers, Mechanics and Students. By William Kent, M.E., Sc. D. Eighth Edition, Rewritten and Enlarged. xl, 1,461 pages. 16mo morocco. Price \$5.00 net. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Kent's pocket book has been before the engineering profession for fifteen years and has attained a high position as a collection of data and reference information, especially in connection with the work of the mechanical engineer. Since the issue of the seventh edition, in 1904, the progress which has been made in all departments of engineering work has been rapid, and much matter which was current practice at the time of the preparation of the original work has become obsolete. Under such conditions a new edition has been considered advisable, and since the original plates had become worn it was decided to reset the whole work and thus permit the thorough revision necessary to bring it up to date. This work has been well done by Mr. Kent, nearly five hundred pages having been added, while more

than one hundred and fifty pages of old matter have been eliminated. The book, as thus revised, becomes still more necessary to the mechanical engineer, and its usefulness will doubtless become more extended than ever.

Lack of space prevents a detailed enumeration of the valuable matter which has been added to this new edition, but the departments which have especially been increased are those relating to materials of construction, mechanics, heat, steam boilers and engines, power and transmission, machine shop, refrigeration and electricity.

Electricity

Dynamo Building for Amateurs, or How to Construct a Fifty-Watt Dynamo. By Arthur J. Weed. Illustrated. pp. 110. Price, Cloth, \$1.00; Paper, 50c. New York: The Norman J. Henley Publishing Co.

This is a very commendable little book, not only because it gives detailed information about the making of a small electric generator or motor, but also because it enables the amateur mechanic who has sufficient skill and equipment to make something really useful and instructive instead of expending his energies in constructing some pretty model which is only fit to be looked at after it is made. No better exercise, both for the head and the hands, could well be imagined than the making of this little dynamo, and the manual worker and amateur should welcome just such useful information.

Formerly the amateur who possessed a lathe and some good tools expended his efforts in making model steam engines, locomotives and similar machines, interesting and instructive in a certain fashion, but of little or no practical service afterwards, and serving only as examples of his skill. Such a machine as is described in this book, however, is both a subject for manual skill and a valuable possession after it is built.

Physics and Mechanics

The recent publication of Franklin and MacNutt's "Mechanics and Heat" not only makes available an excellent text for use in special courses, but, by completing the series in which appear the authors' "Electricity and Magnetism" and "Light and Sound," also makes available an admirable text for a course in General Physics offered to engineering and technical students.

A third edition of Hancock's "Applied Mechanics for Engineers," in which all of the typographical and other errors—inevitable in a first edition—have been eliminated, has recently come from the press. The fact that a third edition has already appeared is in itself sufficient testimony of the success which has attended the use of this book.

Southall's "Geometrical Optics" is arousing the interest of all instructors and students who are interested in this branch of Physics, which has so long been neglected on this side of the water. The book is, without question, the only complete and up-to-date treatise on the subject in English. These books are all published by the Macmillan Company, New York.

Practical Books for Industrial Workers

Industrial workers, engineers, managers of manufacturing plants and others frequently have need to refer to practical books for information, and those who are learning various trades and technical professions must have such information in order to perfect their knowledge in any chosen avenue of industrial activity. Those who are interested in practical and scientific books will find them described in the Norman W. Henley Publishing Company's catalogue, which will be sent gratis to all our readers by addressing the above firm and requesting a catalogue. Address the Norman W. Henley Publishing Company, 132 Nassau street, New York.

Flying Machines and Rivers

The rivers, once the chief lines of intercourse on the earth's surface, were made to give up their prestige to the railway, but the new champion of travel, the perfected flying machine, will bring back to the rivers in the near future the credit of being the highways of commerce and travel. Their flowing expanses of smooth water will offer to passenger and burden-carrying flying machines surfaces from which to rise and upon which they may descend in safety. And the ocean itself may yet prove to be the scene of the greatest exploits of the aviator. Something besides his wings sustains the flying man; it is his confidence, backed by the confidence of the people. Crowds used to gather to see him fall; now they come to see him fly.—*From Augustus Post's "The Evolution of a Flying Man" in November "Century."*

Books Received

Electricity Practically Applied. By Sydney Whitmore Ashe. New York: D. Van Nostrand Co. Price \$2 net.

The Tesla High-Frequency Coil. By George F. Haller and Elmer Tilting Cunningham. New York: D. Van Nostrand Co. Price \$1.25 net.

A History of the Logarithmic Slide Rule. By Florian Cajori. New York: Engineering News Publishing Company. Price \$1.50 net.

Wireless Telegraph Construction for Amateurs. By Alfred Powel Morgan. New York: D. Van Nostrand Co. Price \$1.50 net.

The History of the Telephone. By Herbert N. Casson. Chicago: A. C. McClurg & Co. Price \$1.50 net.

High-Speed Steel. By O. M. Becker. New York: McGraw-Hill Book Company. Price \$4 net.

Dynamo-Electric Machinery. By Samuel Sheldon and Eric Hausmann. New York: D. Van Nostrand Co. Price \$2.50 net.

Applied Thermodynamics. By H. W. Spangler. Philadelphia: J. J. McVev.

Westinghouse Electrical Equipment in Mexico

MESSRS. G. & O. BRANIFF & CO., of Mexico City, who are agents in Mexico for the Westinghouse Companies, have recently supplied electrical and mechanical equipment to several important undertakings.

Cia. Minera Santa Ana y Anexas of Pachuca, State of Hidalgo, Mexico, have entirely equipped their property with electric apparatus, the power for operating being purchased from the Cia. Electrica é Irrigadora. The power is furnished to the mining company at 6,000 volts, 50 cycles, and, in order to reduce this voltage to 400 volts—that required by the motors—a large bank of oil-insulated transformers with protection apparatus has been installed. A part of the equipment comprises a large Wellman-Seaver-Morgan electric hoist, which is double-drum and fitted with brakes and clutches operated by air supplied from a separate electric-driven air compressor. The capacity of this hoist is 9,000 pounds total load at a hoisting speed of 700 feet per minute. The hoist is fitted with post brakes and a 225 horsepower, 400-volt hoist motor of three bearing type with usual controlling device, as furnished by the Westinghouse Electric & Manufacturing Company.

The people of Guadalajara, Mexico, are especially interested in the new packing house which is being constructed in their city. That everything in connection with it is to be strictly modern is evidenced by the fact that it will be operated throughout by electric motors. To equip this, Mr. H. H. Hinkle, the general manager, has ordered, through Messrs. G. & O. Braniff & Co., of Mexico City, a large number of Westinghouse alternating current motors, which will be driven from the local power company's circuit. Between ten and fifteen motors will be installed at first, and some of them are already arriving. All of the mo-

tors will be the new type "MS" mill motors, arranged for driving the various machines, such as tankage mill, fertilizer dryer, killing beds, shops, lard roll, horn saw, clay kettle, etc. The water supply for the power house, as well as the condenser water and sewage, will all be taken care of by "Enke" pumps driven by Westinghouse direct connected motors.

The Negociacion Minera Santa Maria de la Pax y Anexas, located at Matehuala, S. L. P., Mexico, which is one of the largest mining companies in Mexico, have recently installed and just placed in operation two large vertical triplex Gould pumps to handle their mine water. These are duplicates, and each has a capacity of 250 gallons per minute against 700 feet working head. Both are operated by direct connected electrical motors, one of the pumps being located at the bottom of the mine shaft, elevating the water half way to the top, the second pump handling the water from there to the surface.

The motors employed are 75 horsepower Westinghouse, Type HF, provided with slip rings and external resistances, which enable them to be brought up to speed gradually. A generating plant on the surface supplies these motors with a 400-volt, 60-cycle current.

Cia. Minera Santa Ines, Carretera, of Pachuca, State of Hidalgo, Mexico, have installed electrical power at their property, in order to operate a new electric hoist they have recently purchased. Their power will be supplied by the Cia. Electrica é Irrigadora, the same being furnished at 6,000 volts. The new electrical equipment comprises several single-phase transformers, which are for reducing the primary voltage to that required by the motors. There will also be provided lightning protection apparatus, switchboard, etc.

The new electric hoist has already been shipped to this company by the English Iron Work Company, Kansas City, Mo., and is double drum, capable of 5,000 pounds total load at

a hoisting speed of 400 feet per minute. The motor provided with this hoist is 75 horse-power, 400-volt, and was made by the Westinghouse Electric & Manufacturing Company.

The town of Zaragoza, State of Puebla, Mexico, is shortly to be lighted by electricity. Mr. J. F. Samperio has provided for the installing of a hydro-electric plant, to be located three and a half to four miles from the town. The source of power is obtained from the stream, which furnishes an available head of about 200 feet. The prime mover will consist of a 250 horse-power Pelton-Francis turbine, complete with oil pressure governor and all usual accessories. This water-wheel will make 900 revolutions per minute, and to it will be coupled a 125-kilowatt Westinghouse electric generator. This generator will supply electric energy at 3,300 volts, at which voltage the power will be transmitted direct to Zaragoza, where the necessary transformers will be used to reduce the voltage to that required by the arc and incandescent lamps. The power house is also provided with an exciter, switchboard, lightning protection apparatus, etc.

This is one of the many small towns which are now availing themselves of nearby water power illumination.

Economy and Efficiency in the Design of Special Manufacturing Plants

REGARDING the difficulty of obtaining common-sense, practical advice in connection with the design of special manufacturing plants, the Griscom-Spencer Company, West Street Building, New York, is offering the services of its engineering department for this specific purpose. The manufacturing business carried on by this company gives it an excellent knowledge of commercial necessities in the construction of manufacturing plants where, for a given outlay, a satisfactory profit must be secured, or the

operation is a failure. Purchasing for its existing wholesale supply business, the Griscom-Spencer Company enjoys advantages which are of value in decreasing the cost of design and construction of plants.

Co-operation is the keynote of this special service. It ought to be possible for a specialist familiar with the peculiar needs of his factory processes, working with practical engineers familiar with construction problems in general, to produce a plant considerably more efficient and less costly than for either party working alone.

The Griscom-Spencer Company is familiar with manufacturing problems through its operating its own shops at Jersey City, where are manufactured the Reilly multicoil feed-water heater, the well-known Goubert feed-water heater, the Stratton steam separator and the Reilly multicoil evaporator.

The drawings and patterns of the Goubert Manufacturing Company have been taken over by the Griscom-Spencer Company, who are filling orders for Goubert heaters of every size. Mr. A. A. Goubert is now connected with the Griscom-Spencer Company, and has general charge of the heater sales.

Gas Turbine in France

Recent information concerning the development of the gas turbine in France shows that the subject has by no means been abandoned. The Armengaud and Lencale machine, which has already been described in this magazine, has been shown to be based upon correct principles, and the use of water injection with the hot gases is effective in keeping the temperatures within practicable limits. The real difficulty lies in the production of a satisfactory rotary air compressor, of high efficiency and moderate weight. This portion of the problem is now being actively investigated, and before long substantial results may be expected.

National Society for the Promotion of Industrial Education

The Fourth Annual Convention of the National Society for the Promotion of Industrial Education will be held in Boston, November 17, 18 and 19. On Thursday the day session will be held at Perkins Hall, 264 Boylston street, and on Friday and Saturday the day sessions will be at the hall of the Boston Public Library, while the session of Friday evening will be held at the Massachusetts Institute of Technology. Hotel headquarters will be at the Hotel Lenox. Further information can be obtained by addressing Mr. A. Lincoln Filene, Chairman Boston Committee on Convention, Room 1,115, 101 Tremont street, Boston, Mass.

Metal Preservative

Under the title of "The Ideal Metal Preservative" a book is just to hand from Heath & Milligan Manufacturing Company, of Chicago, Ill., written by Mr. Hans Mannhardt, the well-known chemist, and devoted to Mindura paint. This book contains many facts of interest concerning the preservation of steel and iron, facts that the average technical man has neither the time nor opportunity to collect and correlate. The book is worth while, and a copy can be obtained by addressing the company.

The development of flying machines, as indicated by the recent trials in New York, is dependent to a very great extent upon the motor. It is well known that the motor was the most frequent cause of trouble in the early automobiles, but the motor vehicle could rest quietly on the road while the owner lay on his back and tinkered with valves and carburetors until the trouble was found, or, as a last resort, he could "get a horse" and be towed home. The man in the air, when his motor becomes cranky and refuses to work, has no such opportunity; he must maintain his balance and glide smoothly to earth, meanwhile picking out a comfortable place to land.

Lectures Before the Stevens Engineering Society

THE following gentlemen will deliver lectures on the subjects given before the Stevens Engineering Society of Stevens Institute of Technology:

October 18, 1910—Alexander C. Humphreys, "Membership in Engineering Societies."

November 1, 1910—Irving E. Moulthrop, "The Design and Construction of a Central Power Station."

November 15—James P. Haney, "Art and the Engineer."

November 22—Donald B. Macmillan, "With Peary in the Arctic."

November 29—Harvey W. Wiley, "The Services of Chemistry in the Promotion of the Public Welfare."

December 6—Rossiter W. Raymond, "The Story of an Island."

December 20—David T. Day, "The Origin of Petroleum."

January 10, 1911—Gardner F. Williams, "The Kimberly Diamond Mines."

January 16—James Douglas, "The Development of the Railroad on the North American Continent."

February 7—John A. Bense, "The Catskill Water Supply Project."

February 14—Carl Hering, "The Electric Furnace."

February 20—Frederick H. Newell, "Reclamation."

March 7—William Campbell, "Metallography as Applied to Engineering."

March 21—A. Stanley Mackenzie, "Radioactive Phenomena."

April 4—George E. Hulse, "Illuminating Engineering."

At the seventeenth general meeting of the Electrochemical Society, held at Pittsburg, Pa., an interesting paper was presented by Mr. Jasper Whiting on the Whiting Electrolytic Cell, which was the first authoritative account of the new electrical bleaching apparatus installed by the Oxford Paper Company in its plant at Rumford, Me.

Grinding Machinery

The catalogue just issued by Raymond Brothers Impact Pulverizer Company, 1502 Harrison street, Chicago, is a handsome book, 8 x 11, with a large number of exceedingly good half-tone illustrations devoted to the line of machinery produced by them, such as Low separator roller mills, exhaust fans, etc., which are so largely used in cement plants, etc. The text of this book describes their machines very clearly. There are given on more than a dozen pages of small type names of well-known firms in different lines of work who have installed and are using their machines. The book contains a good deal of information of value and can be obtained on request.

The Westinghouse Electric & Manufacturing Company has just issued a revision of its Circular 1118 on the subject of its Type CCL Polyphase Induction Motors. The circular describes the electrical and mechanical features of these motors and shows some very interesting pictures of their applications. The circular also includes some short descriptions of the various starting devices used with squirrel cage induction motors.

The General Electric Company, of Schenectady, N. Y., has presented the University of Illinois with a recording steam meter, a device which has been in successful use as a means of determining the quality of steam passing any pipe to which it may be attached. The gift was transmitted on behalf of the General Electric Company by its sales manager, Mr. F. G. Vaughan, to Professor Ernst J. Berg, in charge of the Department of Electrical Engineering.

This is the second significant gift that the General Electric Company has made the University of Illinois during the past year, the first consisting of a 100-kilowatt Curtis steam turbo-generator.

The Rothwell Continuous Thickener and Filter

THE COLORADO IRON WORKS COMPANY, of Denver, Col., in their Pamphlet No. 26, describe fully this form of thickener and filter, for which they claim great economy of space and a considerable saving in cost of foundations over round tanks of like capacity, and a high efficiency by the length through which the liquid flows from the feed box to the discharge end, and the greatly enhanced settling effect produced by the inclined baffles.

"Durability" is the title of a booklet received from the Burroughs Adding Machine Company, Detroit, Mich., among other matters taken up being the matter of the long life of their machines. A list is given of firms who purchased Burroughs machines from seventeen to fourteen years ago, when the machine was first placed on the market, and who are still using them, the daily expense of same being from 6 to 7.5 cents a day. This little book is interesting.

Where one desires a typewriter for portable use, the American typewriter, made by the American Typewriter Company, of New York, offers many advantages. This machine, which weighs but 12 pounds, is noted for the simplicity of its construction, a simplicity which, it is claimed, has eliminated twelve hundred easily broken parts of other machines without sacrifice of durability, strength or efficiency.

The American typewriter has the universal keyboard, prints from ribbon, two-color ribbon shift, tabulating indicator, extremely light ball-bearing action to its carriage, and gives perfect alignment and clear-cut impressions, while it is claimed for it that its single type bar, one piece of steel, is non-bendable and unbreakable by any stroke that can be delivered on the key in service.

Notes

The next meeting of the Association of American Portland Cement Manufacturers will be held in the Hotel Astor, New York, on December 12, 13 and 14.

The Executive Committee meeting will be held on Monday evening, December 12. The business meeting of the Association will be held on Tuesday, December 13, and on Wednesday, December 14, an open meeting will be held at which papers of interest to manufacturers and users of cement will be presented.

Of late years there has been a considerable growth in technical education in Southern institutions, much more attention being now paid to such instruction than in the past. A very good illustration of this is shown by the pamphlet recently issued by the University of Tennessee, describing fully, by text and illustration, the work now being accomplished in their College of Engineering, with descriptions of its engineering laboratory equipment.

A copy of this pamphlet may be obtained by addressing Mr. Brown Ayres, president, Knoxville, Tenn.

The New York Engine Company, 165 Broadway, New York, claim that their suction producer-gas engine, in combination with their gas producer, will develop four times the power with the consumption of the same weight of pea coal that the high-speed, non-condensing steam engine will. They also state that it will require less attention, less water, require one-quarter of the coal, and is just as reliable and durable. They will be glad to furnish information to those who are interested.

This magazine has secured space at the Aero Show, to be held at Mammoth Coliseum Building, St. Louis, Mo., November 17-24 next, and will be represented there by Mr. William A. Wadsworth, our Western representative.

Personal

Mr. David Gaeher, the well-known contracting engineer, of Cleveland, Ohio, has been forced by the growth of his practice to move his offices from 1135 Schofield Building to Suite 950-952, Rockefeller Building, where will be continued his present line of work, conveying, elevating and transmission machinery, and such natural adjuncts as power equipment used in connection with same, also devoting his attention to the design and construction of special machinery.

Morgan Brooks, M.E., professor of electrical engineering, University of Illinois, has resumed his work with the Department of Electrical Engineering after a year's leave of absence, in the course of which he has made a trip around the world for study and recreation.

Mr. George H. Gibson presented a paper on "Condensers for Small Central Stations" before the Missouri Electric, Gas, Street Railway and Waterworks Association at their last annual convention.

Announcement is made of an important change in the management of the Goldschmidt Thermit Company, of 90 West street, New York. On October 1 Mr. E. Stutz, vice-president and general manager, retired from the direction of the company, which passed under the management of Mr. William C. Cuntz. Mr. Cuntz brings to his position a thorough knowledge of the steel business and a wide acquaintance with the railway and street railway officials of the country, having been connected for eighteen years with the Pennsylvania Steel Company.

Mr. H. J. Mauger presented a paper on "The Introduction of Current-Consuming Devices" before the Indiana Electric Light Association at their Indianapolis (Ind.) meeting.

Progress in Aviation

WITH the conclusion of the international aviation contests at Belmont Park, New York, there has been given to the world a most remarkable example of the rate at which the practical conquest of the air by the "heavier-than air" machine has been developed. Three years ago it was hardly believed that such machines would ever come within the bounds of practicability, and the few demonstrations which had been made sustained this view for many persons. Then came the demonstrations of the Wright brothers in the United States and in France, and it was admitted that a few skilled individuals might be able to remain in the air for a short time, and even succeed in ascending to heights of a few hundred feet.

Since then history has been rapidly made in this most remarkable department of engineering work, and to-day the altitudes have reached several thousand feet, the aerial speeds attained exceed those of the swiftest express trains, and the machines and their passengers remain in the air for hours at a time. Flying is no longer limited to the confines of selected grounds, but is effected over irregular country, across bodies of water, and over the roofs of great cities, points into which a fall would be most disastrous, if not fatal.

Under such circumstances the archaic position taken by the military and naval authorities of the world becomes almost grotesque, recalling the manner in which the work of Fulton, both beneath the surface and upon the water, was received by the conservatives of his time. The nation which has sufficient foresight to cease building Dreadnoughts and begin the construction of fleets of aerial craft will be in a position to dictate its own terms in the next contest, or, better still, be able to prevent the occurrence of any contest whatever. It is of small use to be classed among the followers at the present time, and those who would be leaders should look to the engi-

neers rather than to the politicians if they would keep in the front of the rapidly advancing procession.

The Hi-Lo Desk Attachment

IN the present day of high rents, when it is the object of everyone to use to the best advantage each foot of space in their office, such a convenience as the Hi-Lo desk, manufactured by the Hi-Lo Desk Company, 154 Nassau street, New York, is much appreciated. This contrivance converts a roll-top desk, with low chair, in one minute into a standing desk, thus enabling the user to change



THE HI-LO DESK ATTACHMENT

his position and work as often as he may choose, and to do it instantly, without disturbing the papers or other things on his desk. The device is inexpensive and very practical.

The same firm has recently placed on the market their mail-wrapper tube, "the mailing tube that comes in a flat sheet," whereby manuscript or other matter, after being safely rolled, may be locked in its wrapper, absolutely preventing loss in the mail, while the recipient need only loosen the cords to remove the contents.

Descriptive booklets will be sent on request.

Directory of Wireless Telegraph Stations

WITH the publication of the government wireless telegraph directory, just out, some idea is gained of the extent to which the wireless is now used. In this directory, perhaps the most extensive in existence, there are listed 1,520 stations. This total includes shore stations and ships, but does not take into consideration the warships of foreign governments, nor are listed the hundreds of stations equipped and operated by amateurs, which are the cause of considerable annoyance to the regular stations.

The directory is the work of the Bureau of Steam Engineering of the United States Navy. It is most comprehensive. First are listed the wireless telegraph shore stations throughout the entire world, according to country, giving call letters, wave length, power, range, and character of station. There are about 700 of these shore stations scattered about the globe. Of this number 88 are on the Atlantic and Gulf coasts of the United States, 3 in the interior, 48 on the Great Lakes, 51 on the Pacific Coast, and 16 in Alaska.

A separate list shows the 47 shore stations of the United States Navy and another the 344 ships of the Navy. The stations of the United States Army are listed separately, showing 30 land stations and 16 stations aboard vessels of that service.

In the list of merchant vessels, such as steamships, tugs, yachts, etc., 821 stations are listed. The vessels call letters and owners, and the apparatus' wave length, power and range in miles are noted. These vessels are scattered over the entire world.

As an index the final list contains the call letters of every station arranged alphabetically. From this, operators can distinguish the name of ship or station calling.

Progress on the International Map of the World

PROF. BAILEY WILLIS, of the United States Geological Survey, who has just returned from a South American tour in the interest of the great geological world map in which the civilized powers are co-operating, has been selected to execute geological investigations in Argentina. The plan has a broad scope, and Prof. Willis will be away two years, and possibly a longer time.

The world map project on which Prof. Willis, on the part of this government, has been working, is expected to occupy at least ten years to complete in this country; and, in view of the inaccessibility of Tibet and portions of South Africa and elsewhere, may never be regarded as finished. Its object is to encourage topographic work universally, to increase geographical knowledge of the world, and to secure a uniform standard and a reliable world authority.

The project is an outgrowth of the conference called by Great Britain and attended by all the Ambassadors at the Court of St. James, when arrangements were perfected for construction of the map on a uniform plan and on a uniform scale of 16 miles to the inch. It will disregard international boundaries, and its sheets, of which 2,640 would be necessary to cover the entire world, are to be laid out according to degrees of latitude and longitude. If all these were put together the great "mother map" might be made into a globe 40 feet in diameter.

One of the provisions agreed upon at the London conference was that all names on the map should be spelled according to the country in which the names are placed, as, for instance, Wien for Vienna and Roma for Rome.

Percival Robert Moses, electrical engineer, was born in New York City in 1874, and received his education in the public schools of that city, in the course of three years' sojourn in Berlin, Paris, and Florence, and at the School of Mines of Columbia University, from which he was graduated in 1895 with the degree of Electrical Engineer. After practical work with the Sprague Elevator Company he opened an office as consulting engineer in 1897, since which time he has devoted himself to all the factors entering into the mechanical and electrical operations of buildings and manufacturing plants. He has devoted himself especially to the development of isolated electrical plants, and has been consulted in more than 100 such installations, ranging from 25 to 2,000 kilowatts capacity, and including hotels, office buildings, apartment houses and manufacturing establishments. He is considered as an authority upon the subject of isolated plants, and upon the reduction of operative wastes, and in connection with this work has organized the Engineering Supervision Company and the Isolated Plant Magazine. He is a member of the American Institute of Electrical Engineers, of the Society of Illuminating Engineers and of the Gas Power Section of the American Society of Mechanical Engineers.



Photograph by Pach, New York.

PERCIVAL ROBERT MOSES

ELECTRICAL ENGINEER

See Reverse Side.

CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

VOL. XXXIX

DECEMBER, 1910

No. 2

MANGANESE STEEL

By J. F. Springer

MANGANESE is a grayish-white and brittle metal, somewhat resembling cast iron. Its atomic weight and specific gravity differ but little from those of iron. However, it is non-magnetic and brittle. Prepared by reduction of the chloride, it is exceedingly hard, even excelling steel in this respect. Its fusion point is about 3,347 degrees Fahrenheit, or about 700 degrees higher than that of pure iron. The first piece of pure manganese produced was in 1774. Apparently, however, no important commercial uses for pure manganese have been found so far. This chemical element is found nowhere in a pure state. This is due, no doubt, largely to its affinity for oxygen. Alloyed with iron it has a high value in the steel industry. At the final melting it becomes necessary to get rid of the oxygen combined with the iron; or it may be needful to eliminate sulphur. Because of an affinity for these substances higher than that possessed by iron, manganese is a splendid reducing agent.

But the employment of manganese in the iron and steel industry is not direct, as the pure substance is not used. Instead, the two iron alloys—spiegeleisen and ferro-manganese—are employed. In the United States,

there was in 1908 manufactured 111,376 tons of spiegeleisen and 40,642 tons of ferro-manganese. The imports for the year 1908 were 4,579 tons of the former alloy and 44,624 tons of the latter. It will be seen from these figures that America manufactures its own spiegeleisen and nearly half its ferro-manganese. If the alloy contains less than 20 per cent. manganese it is called spiegeleisen; if more than 20 but less than 90 per cent. ferro-manganese. As both spiegeleisen and ferro-manganese contain carbon, they are also used in the manufacture of Bessemer steel, to impart the right carbon content, subsequent to the decarbonization in the converter. They are also introduced into melted steel to deal with phosphorus and sulphur. This is accomplished by the formation of compounds with them. All of these uses are the ordinary ones. But somewhat more recently the iron alloys of manganese have found a new application in the manufacture of what is called manganese steel.

The term *manganese steel* is not applied to steel having simply a manganese content. It is necessary that the percentage shall be about 7 or more. In fact, nearly all steels contain a small proportion. When the content lies between $2\frac{3}{4}$ and 7

per cent. the steel is generally quite brittle. When, however, the upper limit is well past, a new substance emerges. Instead of a highly brittle metal, the manganese steel thus produced is a very tenacious and strong material. This is a marvelous result, but not an unexampled one. R. A. Hadfield called attention, over a score of years ago, to a similar behaviour of copper-and-tin alloys, as observed by Fesquet. When the proportion of the tin is distinctly less than that of the copper the alloy is hard and brittle. And when it is about one-half that of the copper the substance is exceedingly hard and quite brittle. But when the content of the tin begins to exceed that of the copper a change to a softer character commences. Now steel, having a manganese content of between $2\frac{3}{4}$ and 7 per cent., is practically worthless, because of its brittleness. With certain larger percentages, however, it becomes very tough and strong. That steel with a moderate manganese content is quite fragile will readily be understood when it is considered that a cast bar containing 4.45 per cent. of manganese and having dimensions of $2\frac{5}{8}$ feet x $2\frac{5}{8}$ feet x 30 inches, when supported by bearings 24 inches apart, broke with a load of 8,400 pounds. This is about one-third the strength of cast iron under similar conditions. Another example is that of pieces having a manganese content of 4.90 per cent. which were reduced to a fine powder by ordinary hammering.

Now, not only does the higher proportionate quantity of manganese impart an increased toughness, but this quality is capable of further augmentation by a quenching treatment; for true manganese steel is like copper, in that heating and quenching produce a contrary result to that observed with pure carbon steels. Thus, to cite an example of R. A. Hadfield, a forged piece of the metal, into whose composition manganese entered to the percentage

of 13.75, withstood subsequent to the "water-toughening" procedure a tensile stress of about 73 tons per square inch. The elongation was considerable, having been 50.7 per cent. Another specimen, presumably of similar composition, withstood a tensile stress of 114 tons per square inch, if the area of the fracture be taken as the basis of calculation.

It is said that the content of manganese corresponding to maximum brittleness ranges in the neighbourhood of 4 or 5 per cent. It might be thought that brittleness would manifest itself in a direct correspondence with the carbon percentage. But the reverse is rather to be taken as the case. Thus, very brittle samples contained but little more carbon than mild steel. These specimens were excessively hard. The brittleness is to be explained as due to the peculiar crystalline structure. It is said that such steel can be improved by forging, but not sufficiently to give it commercial qualities.

True manganese steel, however, is tough, whether cast or forged. If heated to a dull red, it may be softened by quenching. Such steels are called self-hardening, because if heated, say to a bright red, and allowed to cool slowly, they will be found to be quite hard—sufficiently so, indeed, to enable them to be used for tool material. At the very beginning of the introduction of manganese steel (about 1884), attempts were made to cast tools. An axe cut through cold iron; a second axe received an edge comparable with that of a razor. Indeed, cast razors were experimented with, and not without some success. A pipe was cast of about 9 inches diameter and $\frac{3}{8}$ -inch wall. This section, 3 feet in length, was tested hydraulically to a pressure of 5,600 pounds per square inch without rupture. To carry the test to destruction required an additional 10 per cent. pressure. Indeed, destruction was not then complete, as the fracture was not one-half the length of the pipe.

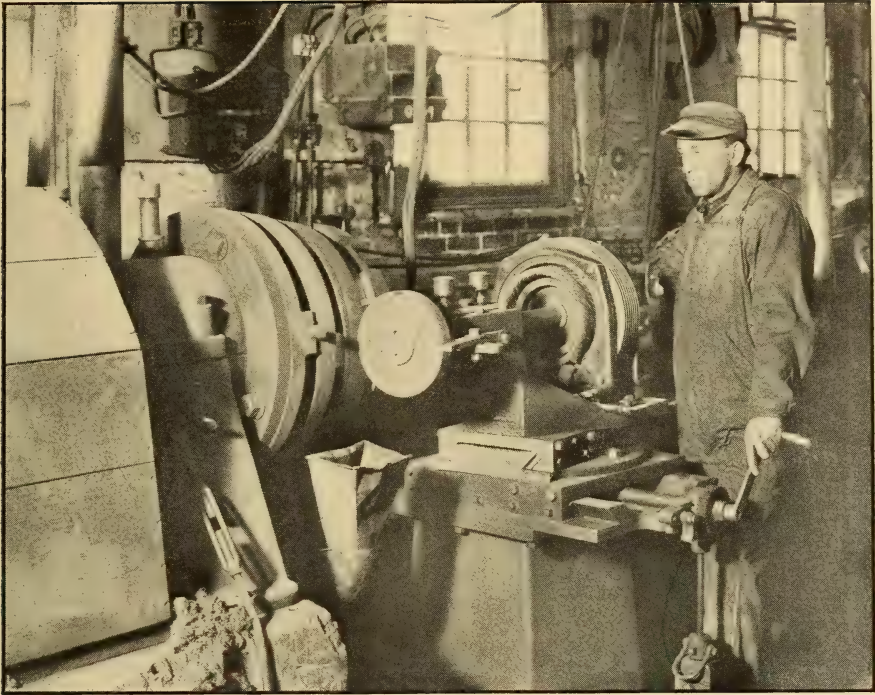


FIG. 1.—GRINDING A MANGANESE STEEL SAFE DOOR

It was early determined that a combination of high percentages of both carbon and manganese did not preclude forging. Thus, manganese steel containing as high percentages of carbon as 2.10 and of manganese as 21.69 may be forged.

Now this steel, whether cast or forged, was at once found to be very refractory. It resisted all reasonable efforts of machine tools. Thus a piece whose manganese content was 14 per cent. required more than an hour for the drilling of a half-inch hole $\frac{3}{4}$ inch deep. The machine was a double-gear, 18-inch drill. Another specimen having a manganese percentage of 12.75 took one and one-half days to turn it an amount which could have been accomplished with mild steel in one-half an hour. But, notwithstanding this refractoriness, manganese steel is not as hard as it appears. It is hard, very hard, but not excessively so. The refractoriness seems to result from a

combination of a moderately high degree of hardness with a very considerable toughness. A moderate blow with a hammer will indent it. In some explosive tests of a safe made of a special modern manganese steel which were witnessed by the writer no difficulty whatever was experienced in making a considerable indentation along the line of the ground-joint between door and body by means of chisel and sledge. In one of the early experiments of a steel with a 10 per cent. manganese content, a round bar 1 inch long and having a cross-sectional area of about $\frac{1}{2}$ square inch was compressed to $\frac{3}{4}$ -inch length by the application of about 55 tons. Even harder varieties, having contents of 15 to 20 per cent., were compressed 0.10 to 0.13 inch. These results are in marked contrast to the resistance to deformation under compressive stresses exhibited by hardened carbon steel and chilled cast iron. Manganese steel seems

truly to have at once disclosed itself as an exceptional material. Perhaps one of the most remarkable characteristics, and one which was early discovered, is the anomalous relation subsisting between its tensile and ultimate strengths. When a bar of mild steel is tested for its tensile properties it may be found capable of considerable elongation. The cross-section will diminish throughout until the maximum load is applied, when the shrinkage will become local. With manganese steel, however, the shrinkage and elongation continue over the entire length. That is, the metal appears to behave uniformly throughout the length under tensile stress. In the case of mild steel, its considerable elongation is combined with a low ultimate strength. By increasing the carbon the breaking load may be augmented, but the elongation will be lowered. There is thus a kind of inverse relationship. But with manganese steel low elongation is combined with low ultimate strength and high elongation with high ultimate strength.

Elongation, Per Cent.	Breaking Load, Long Tons.
22.00	45.97
22.20	45.53
23.42	48.99
24.21	49.07
24.21	50.35
25.00	49.73
25.78	48.95
25.78	50.49
26.56	50.01
26.56	51.18
26.56	50.45
28.90	53.14

Thus a manganese steel having a carbon content of 0.72 per cent. and a manganese one of 10.83 per cent. was tested over a length of 8 inches. The elongation of twelve test bars varied from 22 to 28.90 per cent. and the breaking load from 45.97 to 53.14 long tons per square inch of original cross-section. Upon examining the two columns above, where the elongation percentages and the breaking loads (in long tons) are given, it will be seen even here, where the steel is chemically the same, the variations in elongation and in breaking strength are, on the whole, pretty well in the same direction.

It was thought that the variation in behaviour was to be partly ascribed to irregularity in heating. If, now, America consider the case of a manganese steel where the manganese content was distinctly different, Americans shall have a confirmation of the general proposition that the greater the elongation the higher the breaking load. There were ten test bars here, all of which were heated to a high temperature and then quenched in water to soften them. The carbon content was 0.85 per cent., and that of the manganese 12.29 per cent.

Elongation, Per Cent.	Breaking Load, Long Tons.
33.59	56.74
35.93	55.12
38.28	59.42
40.60	60.73
42.78	58.71
42.78	59.92
44.53	63.84
45.30	62.61
45.31	64.84
50.00	64.84

The averages for the former set of bars were 25.10 per cent. and 49.50 tons; for the latter, 41.91 per cent. and 60.68 tons. All the bars were of $\frac{3}{4}$ -inch diameter. In the case of a third steel, where the carbon had the same percentage as in the last set of bars (0.85 per cent.), but where the manganese content was higher (13.75 per cent.), it was found that, with the heat treatment about the same, three test bars of the same diameter as before gave averages of 46.33 per cent. and 64.25 tons. Another example, where the manganese content was slightly increased (14.01 per cent.), the carbon remaining the same, is that of a test bar having a diameter somewhat less. The elongation here was 44.44 per cent., with a tensile load of 67.13 tons. The bar was still unbroken. The actual stretch of the 8-inch length was $3 \frac{9}{16}$ inches. It is not to be understood that there is any exact correspondence between elongation and breaking strength. There is a broad rule that they accompany each other. This may be well illustrated by citing other bars made from steel of the same composition. A bar cooled in oil had a

percentage of elongation much less (26.56 per cent.); the breaking load was 55.04 tons. Another bar, cooled in air, was stretched 14.06 per cent. under a maximum load of 47.90 tons. Still another bar, forged but otherwise untreated, was elongated only 1.56 per cent.; the tensile load was 36.43 tons. This last bar is said to have disclosed a fracture slightly defective. A mild steel bar of similar size to those cited might be expected to disclose, under same test conditions, an elongation of about 33 per cent. and an ultimate strength of about 25 tons.

The effect of quenching with water is to make the steel stiffer, but, at the same time, somewhat less resistive to a file. The stiffness referred to is in a tensile direction. The effect of the quenching is most marked. This is illustrated by the example of the 14.01 per cent. steel. We may appropriately term the effect *water toughening*. By making a half-and-half bath with sulphuric acid an elongation percentage of 50.7 was reached in a length of 8 inches. The tensile load was here 65.06 tons.

Amongst the early disclosures was the fact that manganese steel was non-magnetic. Steels which have a content less than, say, $7\frac{1}{2}$ per cent. of manganese have some attraction for a magnet. But above 8 per cent. the attraction is practically *nil*. Nor does it make any difference whether the manganese steel has been forged, cast, dipped in oil or dipped in water.

It was desired to ascertain how manganese steel would behave when subjected to the process of wire-drawing. When the attempt was made it was found that it would break up into short sections. The ordinary process of annealing as used with carbon steel was applied, but without success. The quenching process was then tried, and with good results. This "annealing" had to be repeated frequently, as the drawing operation hardened the metal. The frequent heatings to whiteness do not seem to have had any ill effects upon

its tensile strength. Such wire proved capable of enduring tensile loads up to 100 or 110 long tons per square inch. The resistance of manganese steel wire to the electric current was found to be very high. Thus a length of 1,180 yards of 13.95 per cent. steel wire proved equivalent to about 6,000 yards of iron wire or 4,780 yards of the high-priced German silver wire.

The elastic limit of this material was found to be rather lower than was to be expected. A permanent set would begin at a point somewhat lower than was the case with mild carbon steel.

This metal, brought to the attention of engineers in the eighties, has proved a real addition to the list of materials. There are some uses for which it is not adapted. There are others for which it has no commercial substitute. The early experience as to the difficulty of machining has been amply confirmed during the passage of years. The advent of the wonderful high-speed steels does not seem to have appreciably affected the situation. So far as the writer is aware, there is but one commercial method of cutting the material in its hard state. This is by means of the grinding machine. Great difficulty has been experienced in rolling it. However, a number of concerns are now successfully rolling manganese steel rails. Forging and casting have been applied, and with success. In the case of cast rails the rails themselves have proved acceptable, but their price has been enormous. However, the experiments which have been made during recent years have been economically so successful, despite the excessive first cost, that the manganese steel rail is a logical thing, especially for certain difficult services. The shock to which railway rails are exposed is, perhaps, not generally appreciated. It is not simply that a monstrous locomotive has to be supported at a few points of small area, but that this heavy weight is suddenly imposed—how

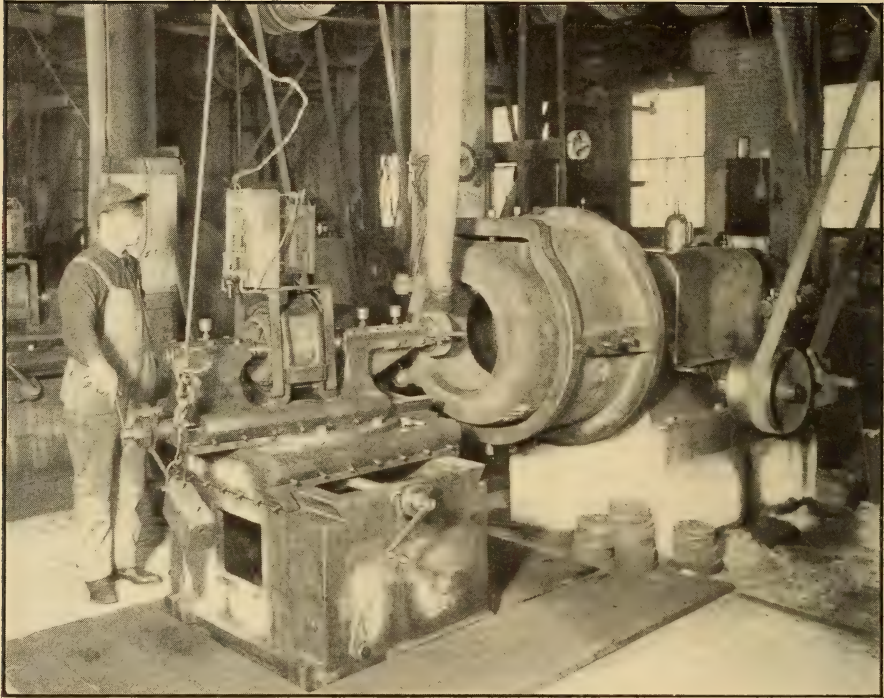


FIG. 2.—MANGANESE STEEL SAFE IN THE GRINDING MACHINE

suddenly depends upon the speed of the train and the diameter of the wheels. The inequality with which the rail is supported gives rise to bending movements between ties. Further, there is an oscillation from side to side of the trucks which produces wear of the inside of the rail heads. A very severe abrasive effect is doubtless produced upon the upper face itself by this side-to-side motion. This is in consequence of the fact that the cone and flange of the wheel are connected by a curved surface whose wedge-like action upon the rail head must be terrific when the flange is forced up close against the side of the head. Now the abrasive actions of the flange itself and of this connecting surface are greatly increased in intensity as the trucks are guided around a curve by the outer rail. In fact, the forward outside wheel of every separate truck must accomplish a tremendous grinding effect upon this rail. The seri-

ousness of this action may be well illustrated by the experience of the Boston Elevated Railway Company. On a certain curve the life of an ordinary Bessemer rail laid on March 13, 1902, was forty-four days. This rail had a weight of 85 pounds per yard, and was of the section known as that of the American Society of Civil Engineers. The head was cut down over three-quarters of an inch in this short time. But let America consider. If the people could substitute for the Bessemer steel in the rail some other material capable of withstanding the abrasion and shock of the heavily-loaded truck wheels, Americans might, indeed, spare the rail; but how about the car wheel? Now it is just here that the manganese steel rail proves its suitability. For it does not secure its results so much by an increase in hardness. Manganese steel is, probably, on the whole, no harder than pure carbon steel of the same carbon content.

But it has high tenacity. The particles cling to each other with wonderful persistence. A manganese steel rail having a carbon content of 1 per cent. differs probably but little from a 1 per cent. pure carbon steel rail, so that we are not dealing with soft material. But it is tough—hard and tough, both. When an abrasive action takes place which would carry off particles of a pure carbon steel, the manganese particles may be somewhat displaced, but they are still there.

The elevated division of the Boston Elevated Railway consists of about 16 miles of track. There are so many curves that they total about $6\frac{1}{2}$ miles. In fact, the passenger on this road is forever turning round. If he makes the round trip of 13 miles between Dudley street and Sullivan square he has experienced about 3,400 degrees of curvature, or about 261 degrees per mile. Nor is the track a level one. And the subway section is considered, both as to curvature and as to gradients, the most irregular portion. On the total mileage of 16 miles, which includes sidings, there are thirty-four curves, none of which has a radius of curvature greater than 150 feet. Eighteen of these have, in fact, radii measuring less than 100 feet each. When the heavy traffic is taken into account, it will not be hard to understand that here we have excessively severe conditions in regard to the wear and tear of rails. And so it was found when the road was put in operation. The outer rail on curves, made of Bessemer steel, had an average life of about two months. So it was not long until the company was in the market for a solution of their problem. Less than a year subsequent to the opening of the line the outer portion of a particularly bad curve of 82-foot radius in the subway section near the Park street station was selected for a trial of cast manganese steel rails supplied in 20-foot lengths by William Wharton, Jr., & Co., Incorporated. At the

time of this installation of the manganese rail and removal of the Bessemer rail about 1,000 cars passed per day. This was a tonnage of about 36,000. The Bessemer rail removed was practically worn out, although in service only forty-four days, having suffered a vertical reduction of the head amounting to 0.78 inch. In the summer of 1908, when it had been in service 2,291 days, or fifty-two times as long as the Bessemer rail, the manganese steel rail was temporarily taken out of the track. Its head had been reduced vertically about 0.55 inch. So, despite the fact that the first cost of manganese rail was, in 1902 and 1903, about \$5 per linear foot and of Bessemer rail about \$0.39, it was very considerable economy to use the new material. In 1908 it was estimated that, with manganese rail costing \$6.70 per foot as against Bessemer rail at \$0.39, the maintenance of the outer rail of the Park street curve for eight years would cost \$7.01 per foot, or \$41.50 per foot, according to whether manganese or Bessemer steel be employed. This estimate was probably based on the use of Bessemer steel containing less than 0.50 per cent. carbon. It is only fair to state that high carbon Bessemer has been found to have a life about four times that of the low carbon variety. This company has made a very thorough test of the manganese steel rail, having used, perhaps, 5,000 feet of it at an average cost of \$6.70 per foot. It was found that, while the vertical reduction went on very slowly, the abrasion of the side of the head proceeded somewhat more rapidly. A steel guardrail was accordingly placed within the inner rail of curves and firmly secured to it. This arrangement permitted frequent lubrication and proved a suitable means of preventing side wear of the expensive manganese rail.

A test of a 6-foot length of cast manganese steel rail similar to that used by the Boston Elevated Railway

was made by supporting its base at two points $4\frac{1}{2}$ feet apart and applying a load at the middle of the length. The load was increased a ton (2,000 pounds) at a time until 64,000 pounds was reached, when the increments were doubled for eleven more loads. This rail weighed 105.75 pounds per yard, and had a height of 5.16 inches. The neutral axis was 2.84 inches from the top. The moment of inertia was 36.875. Upon application of the first ton there was no deflection. The second ton produced a deflection of 0.0110 inch; the third, fourth and fifth, deflections of 0.0197, 0.0288, 0.0372 inch, respectively. The permanent deflection was then observed to be 0.0030 inch. After five more tons had been successively added to the load the temporary deflection amounted to 0.0774 inch and the permanent one to 0.0051 inch. Corresponding figures, after the application of still five more tons, were 0.1190 and 0.0079. The next three 5-ton intervals give the figures:

0.1645	0.0147
0.2210	0.0335
0.2981	0.0735

The increments of temporary deflection for the first 5 tons were, according to the figures given above, 0.0110, 0.0087, 0.0091, 0.0084. These suggest an irregular decrease. Let us note the six 5-ton increments of temporary deflection and the corresponding increments of permanent deflection. They are:

0.0372	0.0030
0.0402	0.0021
0.0416	0.0028
0.0455	0.0068
0.0565	0.0188
0.0771	0.0400

The first column dispels any thought of a decreasing increment of temporary deflection. The rate of permanent deflection, as disclosed by the second column, seems to halt in a curious way and then to augment in a geometric ratio. With a load of 60,000 pounds, the permanent deflection amounted to 0.0735 inch. This is very much more, however, than an ordinary steel rail might be

expected to disclose. Thus, an ordinary steel rail of much less weight (84 pounds per yard), but of equal height, when supported at points $4\frac{1}{2}$ feet apart, had a temporary deflection, when loaded at the middle with 60,000 pounds, comparable with that disclosed under similar conditions by the manganese rail. But its permanent deflection was not more than 0.01 inch.*

A tensile test of a piece of switch rail of manganese steel is interesting, as confirming early observation of uniform stretching. The specimen was drawn down and then annealed. The test bar was $2\frac{1}{2}$ inches long, and had cross-sectional dimensions of 1.26 and 0.28 inches. The tensile strength disclosed was very great, being 134,070 pounds. That manganese steel stretches pretty uniformly over the whole length is illustrated by comparing the cross-section at the point of fracture with that at a remote point. The longer dimensions of the sections were precisely the same—1.16 inches. The shorter one showed a reduction of only 0.01 inch more at the point of fracture than at the remote point. Another test was made with a 16-inch strip having a section of 1.62×0.42 inches. This test piece had been worked at a low red-heat, reheated, and annealed in sand. A tensile load of 40,000 pounds per square inch produced a temporary elongation of 0.05 per cent. There was no permanent set. The tensile strength was found to be 110,000 pounds per square inch. The total elongation was somewhat evenly distributed, as may be judged by noting the elongation of individual inch-sections. These were: 0.07, 0.06, 0.06, 0.07, 0.06, 0.06, 0.03, 0.04, 0.05, 0.05, 0.05, 0.07, 0.04, 0.09, 0.05, 0.03 inch, aggregating 0.88 inch. The contraction of the area at the point of fracture was less than 6 per cent.

The high cost of this type of rail is due especially to the method of

* It is not entirely clear whether this rail stood on its base or head.

manufacture and not to the price of manganese steel. The expense of casting in 20-foot lengths is, of course, considerable. To this must be added the charge for finishing the rough castings by the expensive method of grinding. This general procedure is, of course, unsatisfactory, and men have been diligently seeking a process of rolling. This has not been found an easy problem, for several reasons. In order to make this matter clear, it will be necessary to refer to certain peculiarities. At normal temperatures, manganese steel has a specific heat of 0.145, while at 2,200 degrees Fahrenheit it rises to about 0.200, according to Mr. W. S. Potter. The specific heat of ordinary steel at usual temperatures is 0.117. Assuming that it varies proportionally with that of manganese steel, we get for 2,200 degrees Fahrenheit the value 0.161. In consequence of these values, it will be understood that manganese steel may be expected to cool somewhat more slowly than ordinary rail steel. It might be thought that this would be an advantage, inasmuch as it would seem to permit beginning the rolling operation at a lower temperature. But there is another consideration which must be taken into account. The range of temperature within which, under usual conditions, it would be necessary to roll a manganese rail is much smaller than that which corresponds to ordinary steel. Apparently, this range for manganese steel is about 575 degrees Fahrenheit, as compared with, say, 900 degrees where the steel is of the usual composition; so that, despite a moderate advantage, due to the higher specific heat, it would appear that the rolling of manganese rails would have to proceed with extraordinary rapidity. Ordinary rails are frequently rolled in a period somewhat less than five minutes, according to Mr. Potter. If the specific heats were the same, the drop of 575 degrees would occur in about 192 seconds. But with specific heats

in the ratio of 117:145, there will be a moderate lengthening of the period of drop from 192 to 238 seconds, or four minutes. Perhaps this reduction of the time of rolling might be accomplished commercially. It might be thought that the manganese steel could be rolled from a higher temperature and thus permit a longer period for the rolling. However, it seems that if the metal be heated higher than about 1,875 degrees Fahrenheit it will crush or collapse in the rolls. If the temperature of finishing is carried below about 1,300 degrees, the metal will be so stiff that a disadvantageous amount of work will have to be put upon it. A rail finished thus might, of course, be reheated and quenched. This would have the effect of restoring the toughness. But the beneficial effects of working would inevitably have been obliterated. Further, it is said that this reheating will leave the question in doubt as to whether the metal has not been burned or cracked. That cracking is induced by overheating may be illustrated by an experiment instanced by Mr. Potter. A round bar of manganese steel of, perhaps, an inch in diameter has its temperature carefully raised to a red heat. It is then submerged in a bath of copper, where the temperature would be, say, about 1,929 degrees Fahrenheit. If the bar be tested by bending, it will be found to disclose radial cracks. It is also said that heating much above 1,825 degrees Fahrenheit will result in the production of such cracks, whether water toughening be applied or not. Upon breaking the bar, a columnar structure will be disclosed.

Now, whatever the difficulties of rolling manganese steel rails, and however individual concerns have sought to overcome them, it is clear that they are not insuperable, for at least five concerns—one French, two British and two American—are now able to deliver a rolled rail. Manganese steel seems to pipe more deeply than ordinary steel. This

consideration alone would account for some additional expense in manufacture. Whether the ingot is cropped or compressed or heated at its head, the procedure costs money. On the other hand, blow-holes of any size would seem to be rare or non-existent. This is accounted for largely by the absorption of oxygen by the large percentage of manganese. But, no doubt, the excessive price of manganese rails, whether rolled or cast, is very largely due to

flows of this material. A metal capable of 25 per cent. compression and 35 or 40 per cent. elongation may be expected to respond well to deformation tests. The Manard manganese steel rail of the Pennsylvania Steel Company may be cold twisted until it resembles a piece of steel reinforcement for concrete. A section of rail from the Manganese Steel Rail Company may be pretty sharply curved, with the head of the rail on the concave side of the curve suffer-



FIG. 3.—FITTING THE DOOR TO A SAFE

the slight demand. As long as the use is confined principally to curves the tonnage required can hardly become comparable with that for ordinary steel; so that, unless the treatment during rolling can be made very simple, we may expect the price to be high until the railroads become convinced that here they have a metal economically better than carbon steel for the straight-away track.

Earlier in this account notice was taken of the comparative and tensile

ing severe compressive strains and the base of the rail on the convex side suffering tensile elongations. Or a rail may be bent to an angle of, say, 120 degrees, severely compressing the metal on the head and stretching it on the base. A heavy ring, of the material produced by Schneider & Co., may be flattened in upon itself. There are here very excessive local compressive and tensile strains.

The question of the behaviour of

manganese steel rails at low temperature is, of course, an important one. For railway service, where life and property are so tremendously at stake, nothing but very great certainty of its suitability will justify the use of manganese rails where low temperatures are to be expected. The tests should be made with actual conditions closely approximated. At the same time, it is interesting to know that some simple tests have already been made. At -150 degrees Fahrenheit, a piece of manganese steel wire has been bent double without fracture. The same may be said of another piece at -240 degrees Fahrenheit. Four bars were cut from the head of manganese steel rail, forged, and then sharply bent over, one specimen at each of the temperatures, -10 degrees, -20 degrees, -40 degrees and -60 degrees Fahrenheit, without rupture. At the lowest temperature the radius of curvature was, perhaps, equal to the thickness of the specimen. Similar tests were also made with bars obtained from Bessemer and open-hearth rail heads. But in no case did a test bar survive long enough to permit a deflection of 90 degrees. All this would appear to point in the right direction. Still, tests where the specimen is of full size and where the exposure is long continued are to be desired. Further, such tests should not relate to mere deformations, but should have reference to the effects of vibration and sudden shocks.

Manganese steel has come into very successful railway use at intersections. Here the casting has been the chief factor at the crucial point. However, the point of a frog may be cast, while the heel and wing rails may be cast or rolled. From what we know of manganese steel, it might be thought that the metal would surely flow and form a burr. But this would scarcely seem to be the fact. In one case where the point was cast and the auxiliary rails rolled, there was said to have been "no flow on any of the bars to make

a burr, or even along the edges of the wearing surface." The frog had then seen considerable service.

In order to judge of the hardness of a rolled manganese rail, a cut was made through the rail with a friction disk. In order to remove the skin, which had possibly been affected by the heat, one-sixteenth of an inch was taken off by grinding on a wet stone. The Shore scleroscope was then applied. The very hardest points found were at the fillets joining the under side of the head with the web. Points near the edge of the section and just beneath the two locations just mentioned were nearly as hard. The outer edges of the base were a little softer, but still quite hard. The head of the rail was, on the whole, a little softer yet, averaging about the same as the central point of the web. The centre of the head was the softest location found. All this would seem to indicate that the work of rolling has a hardening effect, just as with metals in general.

The advantages of this material are too evident to permit it to be overlooked by machine builders and others. Thus, the great shovels used in such excavation as that going on in connection with the Panama Canal have oftentimes to deal with a material not earth and not rock. For such use a manganese steel lip is serviceable, as it is both hard and tough. The face plates of lifting magnets must fulfill two requirements. They must be non-magnetic and they must be capable of withstanding severe shocks. Manganese steel answers to both requirements. It might be thought that a lifting magnet performs its service quietly and easily, but a little reflection will convince that the powerful magnetic attraction suddenly created over an irregular pile of pig-iron will be answered by very considerable shocks as the pigs throw themselves against the face-plate. Brass has been used for this purpose, but manganese steel seems to be preferable for severe

service. Crushing machinery employs parts where the abrasive action is terrific. For such usage manganese steel has been found to meet the requirements well. Dredger pins and like parts where the friction is great are advantageously made of the steel. For most purposes the metal is cast. It may then be necessary to finish the pieces by grinding. However, it is claimed that some progress in machining has been made. In accordance with American practice, it is necessary to have a number of holes at the ends of railway rails for the purpose of making a joint by means of fish plates. These holes may be punched even with the metal cold. If recourse is had to drilling, success may be attained, but at considerable expense. It is said that drilling at the rate of 1 inch per hour has been done. This is a very considerable improvement over what was possible in 1901. Further, by heating the metal to about 750 degrees Fahrenheit, it would appear that it may be machined on the planer and shaper. But the grinding machine would appear to be the present means of finishing which is most to be relied upon. It will, therefore, be proper to consider its application to such work in some detail.

The process of grinding depends largely upon the speed of the wheel at the point of contact with the work. It would appear that comparatively soft material is capable of cutting hard if there is sufficient speed. Wrought iron is not especially hard. A disk of this material, when rotated to produce a peripheral speed of, say, 24 miles per hour, can be cut, so it is said, by a graving tool. But if the peripheral velocity be increased to 45 miles per hour, the tool itself may be cut. If the velocity be greatly augmented beyond this point, say to 150 or 200 miles per hour, agate and quartz could be cut. But, as before remarked, manganese steel is not so very hard. The hardest part of a rolled manganese rail has a hardness number ranging around

50 on the scleroscope scale. This is about the hardness of a pretty good tool steel unannealed. It is very much less than the hardness of hardened carbon and high-speed steels, whose hardness numerals average about 100. It seems to be the great tenacity, combined with the moderately high hardness, that renders manganese steel a terror to the machine tool. Tool steels when unannealed are scarcely proper materials for ordinary machine operations, so that, when high tensile resistance is combined with the unannealed tool-steel degree of hardness, it is, perhaps, not so difficult to understand the difficulty experienced in attempting to machine manganese steel. It has, however, been found possible to thread a forged manganese steel spindle commercially by means of a rotating steel disk whose peripheral velocity is high—say, a mile a minute, or 60 miles per hour. Such spindles are threaded by the Ely-Norris Manganese Steel Safe Company at their works in Perth Amboy, N. J. The disk employed is of carbon steel and has a diameter of, perhaps, 6 inches. It is beveled on each side of the rim to produce an ordinary V-groove. The spindles have a diameter of perhaps $1\frac{1}{4}$ inches. There is no especial difficulty experienced in carrying out this operation. It is, perhaps, well not to exceed a speed of about 3,000 rotations per minute, because of the disruptive stresses, due to centrifugal force. These spindles, when the safe is assembled, are placed in the face-plate of the door and are connected with the combination apparatus. The threaded end of the spindle is within, where it engages with a carbon steel part. The threading operation required on manganese steel is an exterior one. Just how the problem could be met for an interior thread is not clear, unless indeed a small disk were employed. To secure the 60-mile-an-hour peripheral speed, such a disk one-half inch in diameter would have to be given an angular velocity of more

than 40,000 rotations per minute. However, this velocity is attainable. But what about the disruptive action of centrifugal force? Will the carbon steel particle of given size which remained in place on the periphery of the large wheel still remain in place on the periphery of the small one? The formulæ for the radial tensions are $C_1 = m_1 r_1 w_1^2$, and $C_2 = m_2 r_2 w_2^2$, where C, n, r, w denote radial tension, mass, radius, angular velocity, respectively. Assuming the particles to have the same mass, we have

$$\frac{C_1}{C_2} = \frac{r_1 w_1^2}{r_2 w_2^2} = \frac{r_1}{r_2} \times \frac{w_1^2}{w_2^2}$$

Since $r_1 : r_2 = 6 : \frac{1}{2} = 12 : 1$, and $w_1^2 : w_2^2 = 3,000^2 : 40,000^2 = 9 : 1,600$, we have

$$\frac{C_1}{C_2} = \frac{12}{1} \times \frac{9}{1600} = \frac{27}{400} = \frac{1}{14.8}$$

That is, the tensional stress on the periphery of the small wheel would be nearly fifteen times that on the periphery of the larger one. Apparently, the velocity of 40,000 rotations per minute for a little half-inch carbon steel wheel is out of the question. If the little wheel be reduced in diameter, a disadvantage results. This will become clear upon considering the following statements: The ratio between C_1 C_2 , expressed in terms of the linear velocities, is

$$\frac{C_1}{C_2} = \frac{V_1^2}{V_2^2} \times \frac{r_2}{r_1}$$

Since the linear velocities of the cutting edges of the two wheels are to be kept the same, we have

$$\frac{C_1}{C_2} = \frac{r_2}{r_1}$$

So that, if we reduce the diameter of the second wheel, we increase the radial tension in the same ratio. This is because the angular velocity has to be augmented in such high degree to maintain the peripheral speed. However, the safe people do not have to solve this problem, as they do not have to cut any internal threads in manganese steel. There is a place

where they need a threaded hole, but they avoid all difficulty by the use of a wrought iron insert, the position being upon the interior and removed from possibility of burglarious attack.

In fact, there are a number of interior locations where a machine operation has to be carried out, and where the difficulty of doing so on manganese steel is avoided by using inserts. But there is a great deal of the hard and tough material itself that must be removed. The safe consists, essentially, of two pieces—the body and the door. The body is a single casting having much the form of a flattened orange. The face, which is one of the flattened surfaces, is perforated by a large hole tapering inwards. Into this opening the door fits—this is, except for the two spindles already mentioned, also a single casting. The front part is a slab of metal perhaps 2 or 3 inches thick, having two perforations parallel to its axis, in which the manganese spindles may be rotated. This slab is perforated radially also for the purpose of the combination bolt. The interior part of the door consists of a very thick slab absolutely solid. The two slabs are joined together by connecting lugs. The space between the slabs not occupied by the lugs is partially utilized to accommodate combination mechanism. At the back of the inner slab the automatic time lock is placed. Also, the inner slab is continued by a shell which surrounds the automatic device and terminates in a series of lugs arranged around the circumference and projecting radially. In the walls of this shell are arranged the bolt holes of the automatic time lock. At the inner end of the opening in the body another series of lugs is cast integral with the body. These correspond to the lugs on the door and project radially inward. The manner of locking the door is to bring it into such a position that the lugs of one set correspond to the intervals between lugs

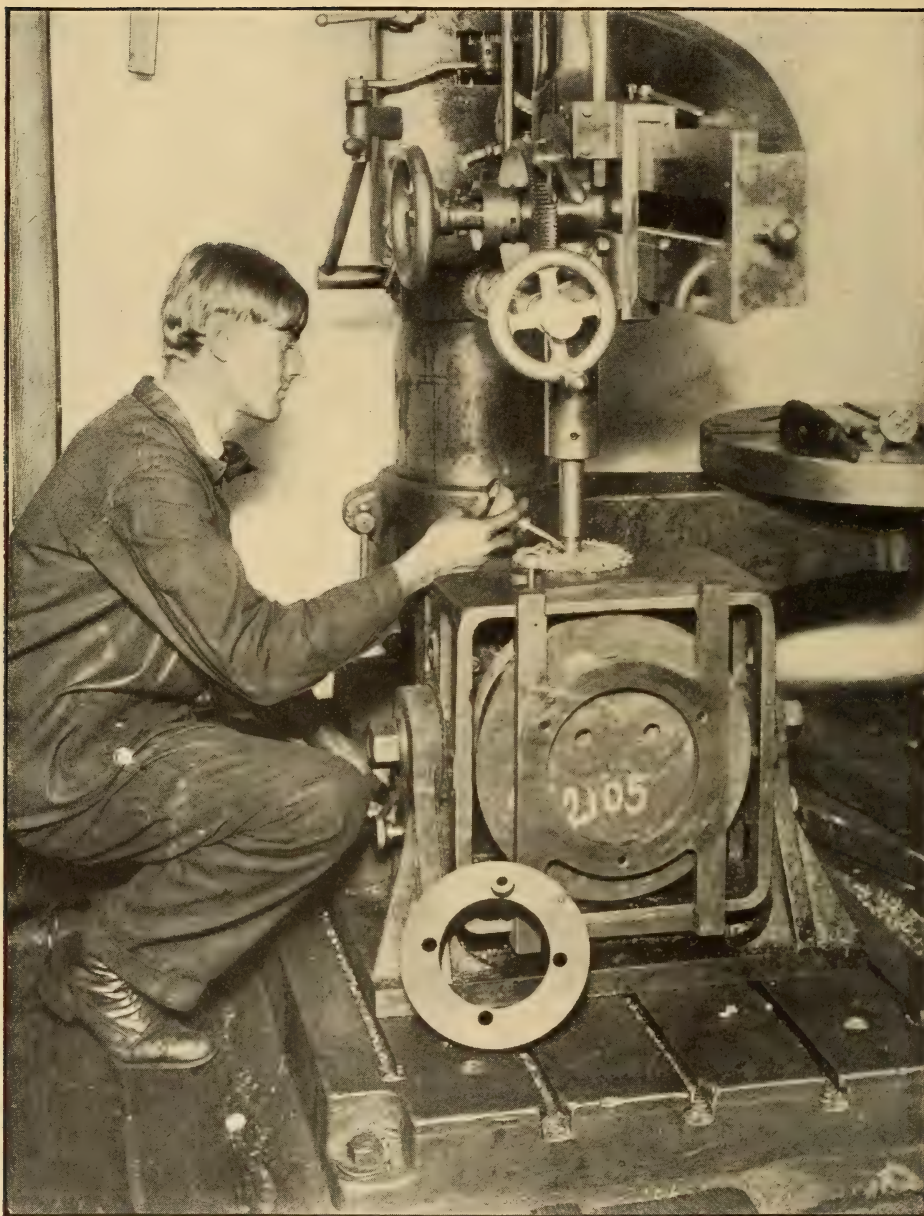


FIG. 4.—DRILLING HOLES IN A MANGANESE STEEL SAFE DOOR

in the other set. This arrangement permits the door to be swung further in until the set of door lugs is just back of the other set. By giving the door a slight rotation, the individual door lugs are brought immediately behind the individual lugs

of the other group and the safe is locked. It will thus be seen that the interlocking of the lugs secures the door to the body. When in this position the door has its bolts shot, and is thus prevented from rotation. These bolts are almost a negligible

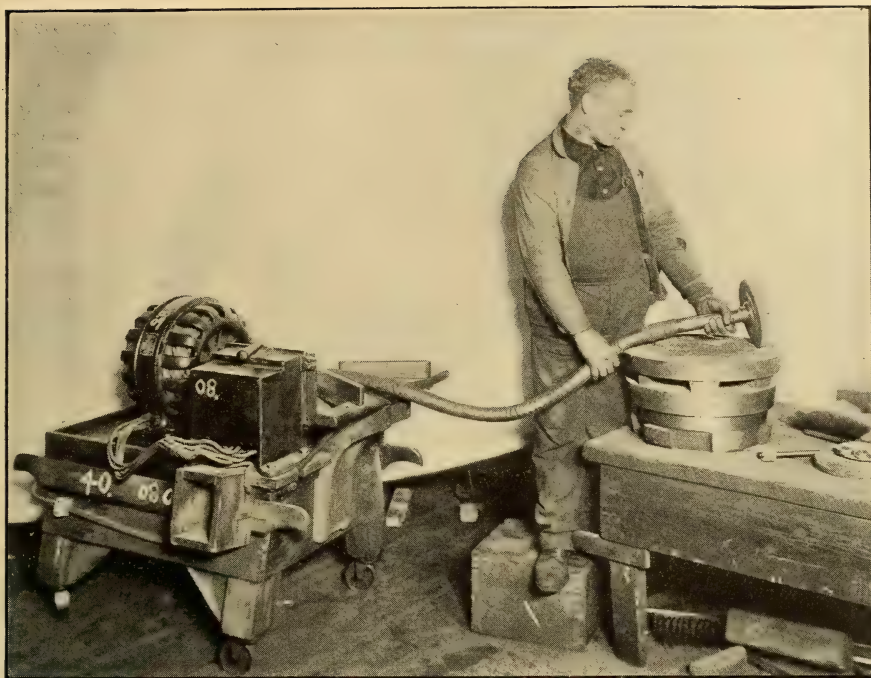


FIG. 5.—A PORTABLE GRINDING MACHINE FOR FINISHING MANGANESE STEEL

factor in the locking of door and body together. They serve mainly to prevent the locked relation from being broken up. The contacting surfaces of the interlocking lugs lie in a plane approximately perpendicular to the axis of the door. There are two methods of arranging these surfaces. One is to have them precisely in the perpendicular plane; the other is to have them all slightly inclined to that plane. The second method is that followed by the Ely-Norris Company. The door is thus forced into its final position by an action which is precisely the same as that by which a screw enters a nut. However, consecutive lugs, whether on door or body, belong to different threads. If there are six lugs in each set there are six threads.

If the foregoing description has been carefully followed, it will readily be understood that there are many surfaces which not only require shaping, but demand an extraordinary closeness of fit. The controlling

reason is to prevent the introduction of nitro-glycerin. The joints where the door contacts with the walls of the hole and where the spindles work in their holes must be beyond criticism. The conical surfaces of the door are cut down and brought to form by a grinding wheel. In Fig. 1 we have shown the mechanism used for such an operation. The door is secured to a suitable face-plate which gives the work its proper slow, rotatory motion. The grinding wheel is mounted on a spindle, on which, in turn, the driving motor is placed. The whole is mounted on a kind of compound rest. The crank upon which the operator's hand rests serves to cause the wheel to advance upon and recede from the work. The grinding device for this movement is to be seen at either side of the threaded shaft. Just above is a similar arrangement to control the direction of the traversing movement of the wheel. This may be swung to obtain the required direc-

tion of traverse. With this direction once secured, the design of the "rest" is such that the same degree of taper may be ground at different locations on the work, irrespective of whether all the tapered surfaces belong to the same cone. The mechanism for the rotation of the work is solidly mounted upon a concrete bed. For accurate work, it is, of course,

the sparks are driven is seen below the wheel.

In Fig. 2 we have a view showing a grinding operation in connection with the body. The heavy piece is firmly secured in a specially formed chuck. This is given a rotary motion by suitable mechanism mounted upon a concrete base. At the moment, the base of the body is



FIG. 6.—A FINISHED MANGANESE STEEL SAFE

necessary to prevent vibration. It will readily be understood that the disposal of the fine particles resulting from grinding operations is a matter to which attention is demanded. A system of air exhaust is quite generally employed throughout the shop for this purpose. In the present view the funnel into which

up. Here, again, the grinding device is mounted upon a kind of compound rest. The crank in the man's hand controls the advance and recession of the grinding wheel along its line of traverse. The crank to the front controls the position of the axis of the wheel. The exhaust pipe is seen with an elbow in the opening of the

work. The two classes of operation described serve to produce conical surfaces very well corresponding to each other as to taper. In order that the two surfaces shall be so related that actual contact will occur when the door has entered a proper distance, the final surfacing is not done on these machines. In Fig. 3 we have a view of a body and its door. By means of a suitable block and tackle the door may readily be lowered into its opening and raised out of it. When down in the opening, it may be given a reciprocating rotary motion by means of the bar seen back of the chains. This is lowered until its outer end rests in a kind of shallow slot in a reciprocating bar. The workman in the view is seen in the act of painting the door with a paint made of loose carborundum. In this way a very accurate fit may be obtained. In order to make an absolutely flush joint on the face, the door is locked in position and the whole properly secured in a special chuck, which, in turn, is bolted to the face-plate of a large lathe. Here the work is rotated, the wheel throwing the sparks upward into the exhaust funnel. Another compound rest controls the movements of the wheel.

But before this last operation is performed a number of others have been carried out. Thus, the inner face of the door has been surfaced; the interior of the cavity where the automatic time device is to be located has been given its finished form. Certain holes have been drilled in the wrought iron inserts. By the use of the jig shown in Fig. 4, it has been found possible rapidly to locate bolt holes in the door. As the metal being drilled is wrought iron, this is an ordinary machine-shop job. A good deal of the metal that requires removal may be taken off without any especial reference to exactness. Thus, in Fig. 5 we have a portable grinding machine where the position of the grinding wheel is determined altogether by hand. Just how portable this apparatus is

may be seen from the fact that it is carried on a simple truck.

The finishing of the holes for the manganese spindles is an interesting stage. These holes cannot be provided for by the use of wrought iron inserts, as their situation is an exposed one. They are cast in the rough and finished by grinding. It is desirable to maintain the axis of the grinding wheel, so that the heavy face-plate is given a slow rotatory movement about the axis. By means of a master-plate not only this movement is given, but provision is made for a quick change from one hole to the other. On the plate is eccentrically arranged in a circular guide a holding device suitable for the door. The door is secured in such a way that the axes of the two spindle holes are equally distant from the axis of the circular guide. It is only necessary, therefore, when changing from one hole to the other to swing the holder in the guide ring sufficiently far to bring it to position. This arrangement for the devices and the door would unbalance the plate if it were not counterbalanced. It is necessary to surface the front slab of the door in the vicinity of the inner end of the hole. This is accomplished by using a cup-shaped wheel, attaching it to the spindle after it has been run through the hole. In Fig. 6 may be seen a safe subsequent to the fitting operations. The joint between door and body is scarcely discernible. It is located at the centre of the outer one of the annular ground surfaces. The holes in the ears provided for the support of the bracket which carries the door are in wrought iron insert. So also are the six holes circumferentially arranged around the face on the rough interior surface. It might be thought that here was a weakness. But every one of these corresponds to a lug connecting the front and rear slabs of the door.

There can be no question of the desirability of manganese steel in the mechanical world. There are too

many situations where the combination of hardness and toughness is highly desirable, not to say indispensable, if the best results are to be secured. In a few such situations the parts made of manganese steel do not have to be accurately finished. The processes of casting and forging may often be sufficient. But if holes have to be drilled and tapped, surfaces planed, an external thread cut, a slot formed, or a turning operation performed, difficulties begin. And in most machine shops these difficulties are probably even to-day insurmountable. As we have seen, the grinding machine is a very possible solution of many such problems. The cutting of an external thread would appear to have had a very thorough solution, the carbon steel disk cutting a clean thread commercially. That the grinding-machine proper is a commercial method may be judged when it is stated that the Ely-Norris Company grind off upwards of 35 pounds of metal in finishing a safe. However, machine-tool builders should not let it go thus. It seems probable that other methods may be devised. The writer would suggest the use of very high speeds combined with a very small area of cut. If a thread can be cut by a kind of abrasive action of ordinary steel, it would seem very reasonable to expect that work rotated at high speed in a lathe could be formed to shape by the use of a cutting area so small that the resulting action would be a kind of abrasion. The speeds usual with our present lathes are entirely too slow. Their rates are scarcely of the order of magnitude required. What is needed is, apparently, a peripheral speed of the work amounting to upwards of a mile a minute. With this high speed of the work should be combined a machine method

of feeding and deepening the cut competent to make a perfectly regular advance by microscopic stages. I am very much inclined to think that manganese steel would yield to this treatment. Similar remarks apply to the milling machine. Here the tool would have to have the speed. To secure an angular velocity of the spindle carrying a cutter of, say, 2 or $2\frac{1}{2}$ inches diameter, amounting to 9,000 revolutions per minute, would, no doubt, call for some changes in present designs. But this is not important. The question of real importance is whether the expected results can be obtained at a commercial price. The feeding of the cutter into the work should proceed by the regular and rapid addition of infinitesimal amounts. This would give an abrasive action. It would appear to be not unlike the action of the thread-cutting disk. That is carried out by very simple arrangements. The general problem can, however, scarcely be solved thus. It may, indeed, require extended experimentation. But the prize is worth striving for, and ultimate success is to be expected. A rapidly moving wheel of emery, carborundum, or the like, is *now* able to effect commercial results. A similar attack made with a steel tool should have good results. Perhaps a steel wheel with a file face might affect the abrasion, especially if the face is continuously cleaned while in action. But whatever the right methods are, America may be quite sure that they do exist, and Americans should not despair of their discovery. Surely America shall be able to deal with this material with all the different machine tools by means of a thoroughly stiff tool, and shall not be mainly dependent upon the grinding wheel!

MECHANICAL APPLIANCES FOR HEALTH AND SAFETY IN THE WEAVING INDUSTRY

By H. M. Crawford

NO fewer than 720,000 looms are employed in the cotton weaving industries of Great Britain. The bulk of these machines is in Lancashire towns and villages, where they find employment for 280,000 operatives. The importance of this vast industry from its "safety" point of view cannot, therefore, be overestimated.

There was a time when safety in the loom-shop was well-nigh absolute. But then the water-wheel and the steam engine had done little for the textiles, and less still for the weaving department. Looms were built, in fashion more or less clumsy, in back kitchens, bed rooms, garrets or third stories, whence they could be dislocated at a few hours' notice if the family contemplated removal to another cottage with easier rent. These looms (Fig. 1) were operated by hand and foot. The foot was in constant use for plying the treadles under the loom. The treadles raised one set of healds and lowered another, so that there was an upper and a lower line of cotton threads—known as the "shedding"—between which the shuttle could be thrown by hand (Fig. 2) from one side of the loom to the other.

This manipulation of the shuttle was an ingenious arrangement devised by John Kay, the famous inventor of Bury. Hitherto the shuttle had been thrown from one shuttle-box to the opposite by two operatives stationed at each side of the loom. Kay invented his picking-stick and attached it to a leather picker in the shuttle box, so that a smart pull on the connecting bands caused the shuttle to shoot from side to side at the will of the weaver. It thus followed

that while the shedding was made by the treadles, the shuttle was shot through with the banded stick, and the weaver with her left hand beat up the weft thread to the cloth.

So beautifully simple was the whole process that young people in their teens could vie with their parents in the management of looms. And the only element of risk lay in the falling of a heavy treadle-weight occasionally on the worker's toes. Every village in northeast and southeast Lancashire had its complement of these hand-looms, while machinery accidents were unheard of.

Then another day dawned—a brighter and better, even though it involved greater risk to the Lancashire weavers. What were termed "steam looms" came on the scene, and a terrible outcry came from the hand-loom weavers themselves. These had a profound objection to working on the new motive power in factories and rose *en masse* for the continuance of the old order of things. Mills were attacked and destroyed, shuttles were stolen, boiler-plugs were drawn and the Lancashire weaving industry was reduced to sheer stagnation.

But the "steam-looms" went apace, after all. Weavers recognized that "hand-loom" days must be superseded. Strong types of machinery were erected by the thousand in sheds all over Lancashire, and the rough wooden frames which had clacked so long in the cottage chamber were relegated to the lumber room.

But a new chapter of casualties arose which well-nigh staggered both masters and operatives. Hands and fingers were lost in toothed wheels, arms were broken and bruised by

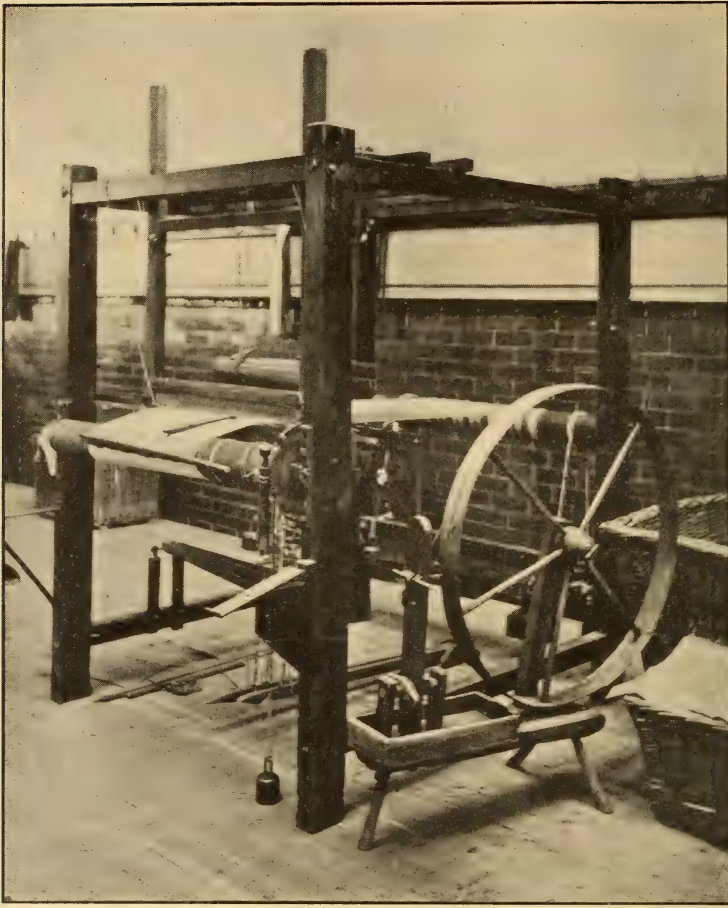


FIG. 1.—OLD HAND LOOM AND SPINNING WHEEL

collision with wheel-spokes and picking-sticks. And these happenings



FIG. 2.—THROWING THE SHUTTLE ON A HAND LOOM

were eclipsed by the more serious injuries wrought from flying shuttles.

These, in their aerial flight, struck the heads of the weavers and in many instances pierced an eye, destroying the sight. The inside walls of weaving sheds were spattered with the dents of flying shuttles. And in so much as any shuttle might fly at any moment, the weaver's life in the mill was surrounded with considerable uncertainty.

For a century at least, in the absence of safeguards, casualties have increased annually with the added number of looms. From small mills with 100 to 150 looms sheds have arisen covering several acres with 2,000 to 3,000 machines.

The enormous expansion in the spinning section of the cotton indus-

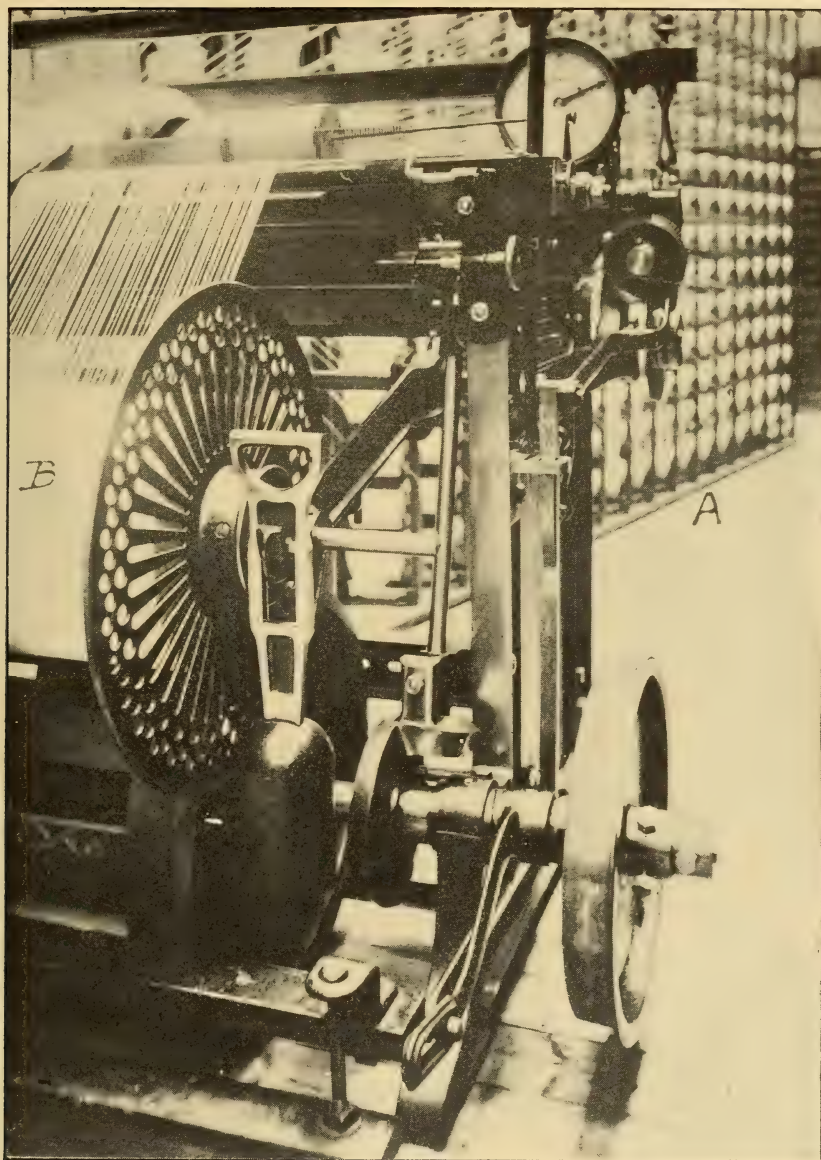


FIG. 3.—WARP CREEL (A) AND BEAM (B) ON WINDING MACHINE

try is largely answerable for the erection of some 25,000 looms during recent years. It is to the advantage of both manufacturers and operatives that all departments of the trade should be approximate to each other. Workers become accustomed to the different phases of treatment of the cotton fibre and the intricate opera-

tions of the machinery. Accidents have shown a remarkable increase where strange hands have been imported from parts of the country where cotton manufacturing is unknown. Lancashire children from their earliest days are accustomed to see the machinery of a cotton factory.

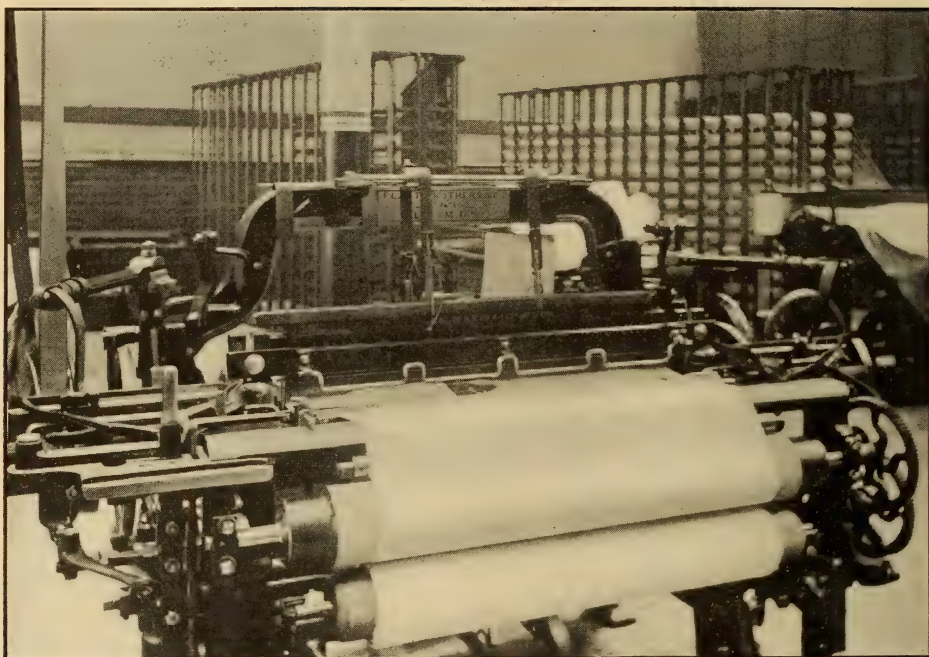


FIG. 4.—SHUTTLE FLYING FROM A LOOM

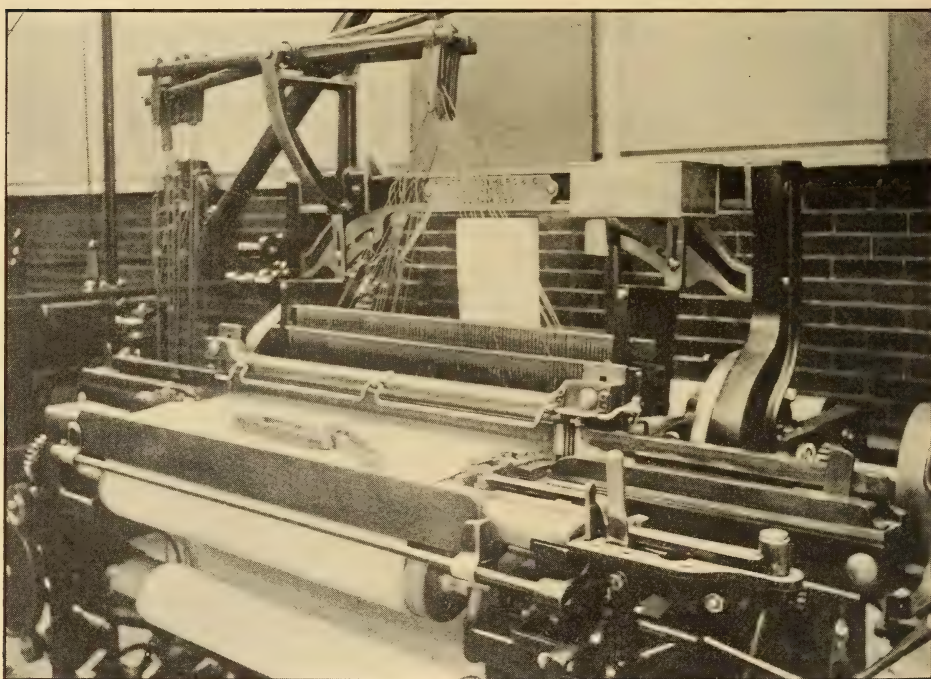


FIG. 5.—SPRING SHUTTLE-GUARD ON UNDER-PICK LOOM

From spinning to weaving is a short step covered by several important operations. The cop of yarn from the mule spindle is ready for the weaver's shuttle as weft, but is not suitable for the warp. Such cops as are, therefore, intended for the warp are placed on the winding machine to be wound on bobbins for the warping creel (Fig. 3). The threads are then wound on a cylindrical beam with side flanges. Sizing follows with china clay, farina, wax, tallow, soda, chloride of magnesium, chloride of zinc and powder blue. These ingredients, in proportions suited to the

requirements of the warp, are added to the threads for the purpose of giving firmness and elasticity, as warp threads are submitted to much greater strain than weft threads. The slashing machinery "sizes" the threads, carries them through a drying process, and winds the contents of several beams on to one for the loom. Then warp and weft are ready for the volitions of the weaver and the activities of the shuttle.

Shuttles are the most dangerous factors of the loom, and commendable efforts have been made by machinists in recent years to construct

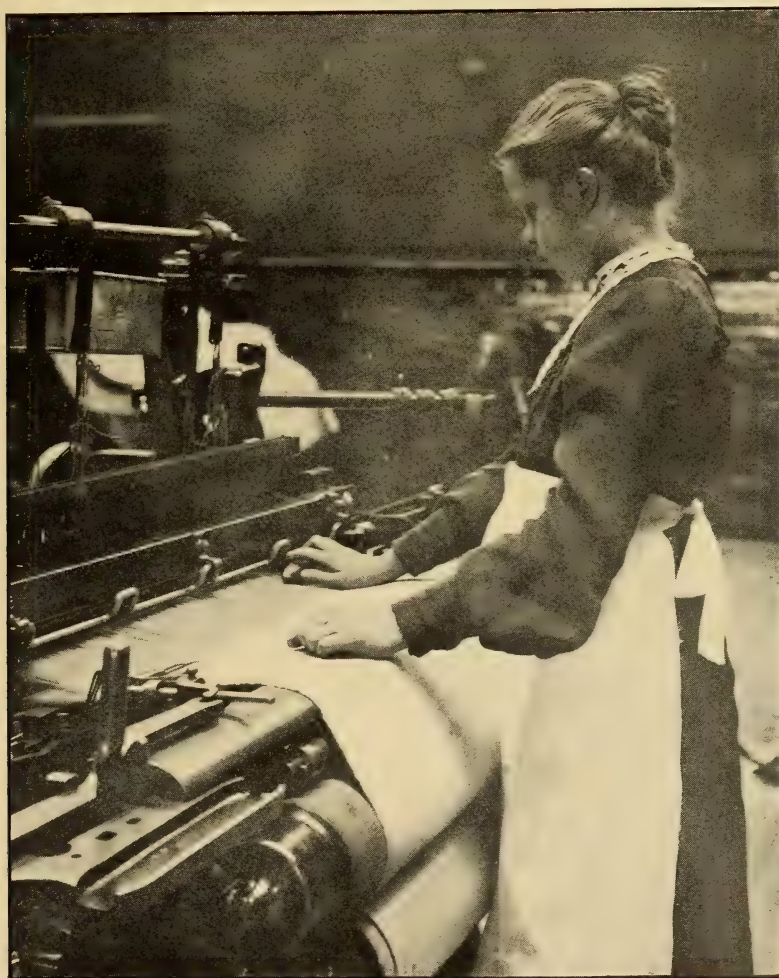


FIG. 6.—A WEAVER AT THE LOOM. GUARD THRUST IN WHILE INSERTING A SHUTTLE

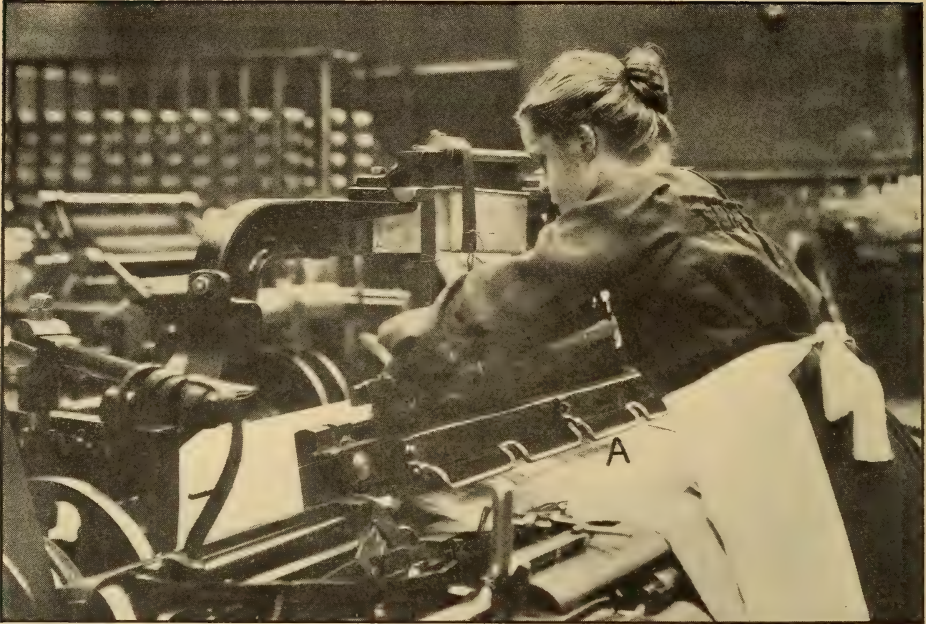


FIG. 7.—SHUTTLE GUARD (A) SPRUNG OUT TO NORMAL POSITION

shuttle guards which are practicable and reasonably protective. The incidence of accidents from flying shuttles, as compared with those arising from other causes, is shown by the following particulars: During the last four years cotton-loom accidents averaged about 670 from all sources, including 128 from flying shuttles, 81 from picking-sticks and pins, 74 from cog wheels and balance wheels, 39 from loom hammers, 28 from tappet and crankshafts, 27 from frogs and duck-bills and 293 from other sources, such as driving straps and pulleys, projecting set-screws and treadles. When we consider that these items come from the use of over 700,000 looms there is much to be grateful for in the fact that for every 100 machines the accident factor amounts to only 0.095.

But there is another view which calls for serious consideration. This low percentage does not in the least diminish the suffering of any operative who may be injured. An eye which is pierced by a flying shuttle is irretrievably lost, and mere figures

afford no recompense. Besides, the liability for any single accident is not affected one iota by the fact of accidents happening rarely or frequently. If an unfenced shuttle "fly" and injure any operative, the resultant expense may reach well into three figures whether any such accident has previously occurred in a given shed or not. The casualty is actionable (1) at common law for neglect to provide proper means of safety; (2) under the Employers' Liability Act for a similar reason; and (3) under the Workmen's Compensation Act. And while the liability of the employer under the Workmen's Compensation Act may not be a serious item, any action taken under the first or second heading may involve an expenditure of hundreds of pounds—through the absence of a shuttle guard costing five shillings.

It is, therefore, of boundless interest to employers—and the insurers of employers—that shuttle guards, and all other known safety appliances, be forthwith provided on looms under their supervision.

Shuttle guards do not prevent a shuttle flying from the loom (Fig. 4), but they so deflect it as to prevent it striking the heads of the workers; and in the generality of cases the persons struck are low of stature or are stooping at the moment the accident occurs. Guards are of various types and patterns. A crude form of guard is used on some looms making 80 to 100 picks per minute. This consists of a stout piece of leather erected vertically at the end of each shuttle-box. A much superior form of guard (Fig. 5) is made of strong steel wire dented for intermediate attachment to the slay-cap. This guard is semi-automatic, in that its attachment contains a spring which allows the guard to be thrust in (Fig. 6) while the weaver is inserting a shuttle; but the moment the loom begins to work the spring forces out the guard (Fig. 7) to its normal position. On many looms the steel wire guard is used as a rigid fixture (Fig. 8), being screwed to the

slay-cap at either end, and, in case of broad looms, at intermediate parts.

It is essential that these appliances be fixed with mechanical efficiency. They should be distant from the slay-cap $\frac{1}{4}$ inch less than the widest part of the shuttle. The length of the guard should extend from the weft-fork on one side to within 6 inches of the shuttle-box on the opposite side. The weaver will thus be able to insert the shuttle in either box without difficulty. Further, the guard should be sufficiently low as to merely clear the cloth holder or "temple."

With shuttles making 220 picks per minute traveling at the rate of 20 feet per second, it will be obvious that efficient guarding is very necessary. Reference may here be made to the practice of "shuttle-kissing" (Fig. 9), so common among weavers. Although it is difficult to imagine that the practice can be otherwise than unhealthy, it is all but universal with the use of eyeletted shuttles. It is true that attempts have been made to

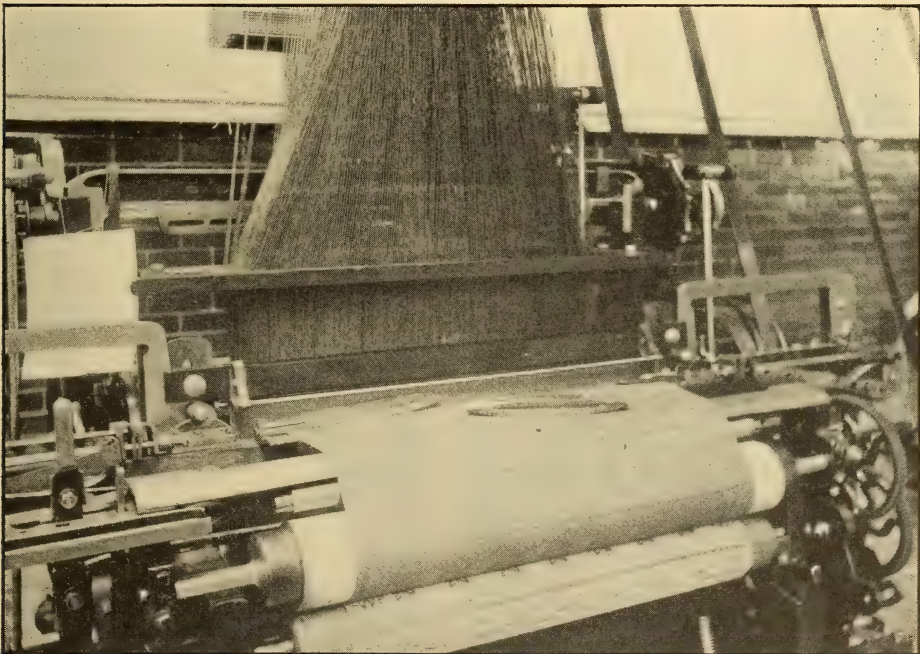


FIG. 8.—SHUTTLE GUARD FIXED ON SLAY-CAP



FIG. 9.—SHUTTLE KISSING



FIG. 10.—THREADING SHUTTLE WITH PNEUMATIC BULB



FIG. 11.—NO SHUTTLE KISSING, THREADING SHUTTLE BY HAND



FIG. 12.—FIXING A COP IN THE SHUTTLE

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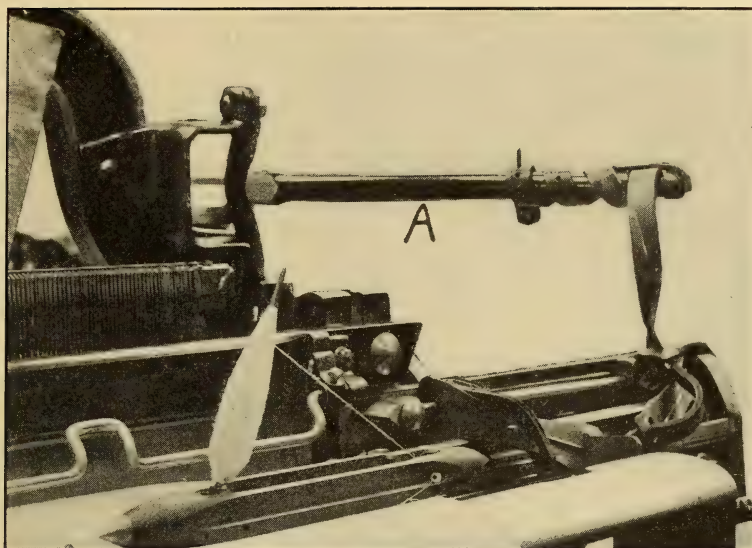


FIG. 14.—PICKING-STICK (A) ON OVER-PICK LOOM

adopt a pneumatic bulb (Fig. 10) for the purpose of sucking the thread through the eyelet, but this plan is not favourably received by the oper-

atives. A much better method is in vogue, by which the weaver ties the beginning of a new cop-thread to the end of an old one. She then draws

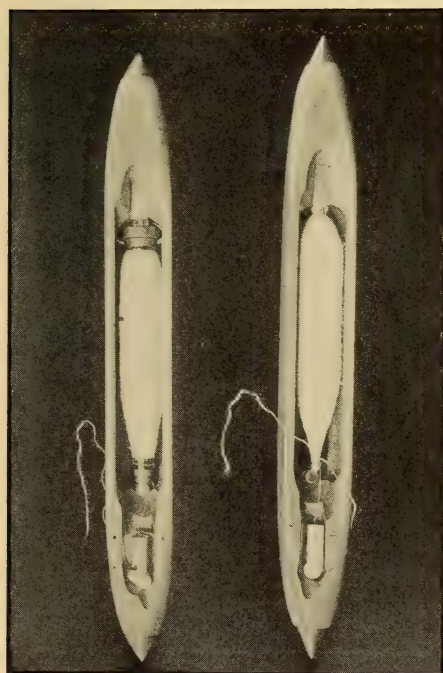


FIG. 13.—WILSON SHUTTLES THREADED BY HAND (A) FOR COPS, (B) FOR FIRNS

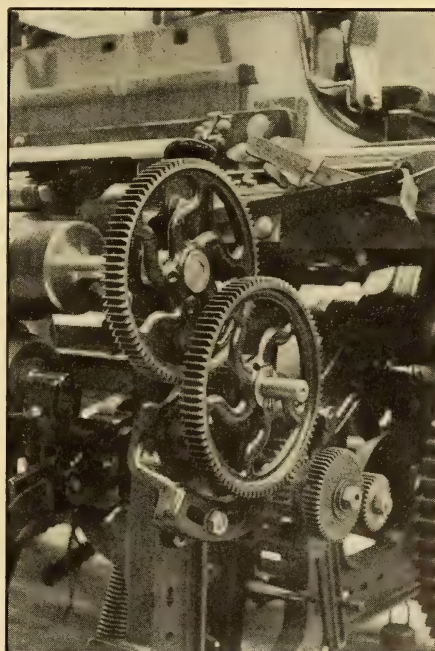


FIG. 15—COG WHEELS OF CLOTH BEAMS

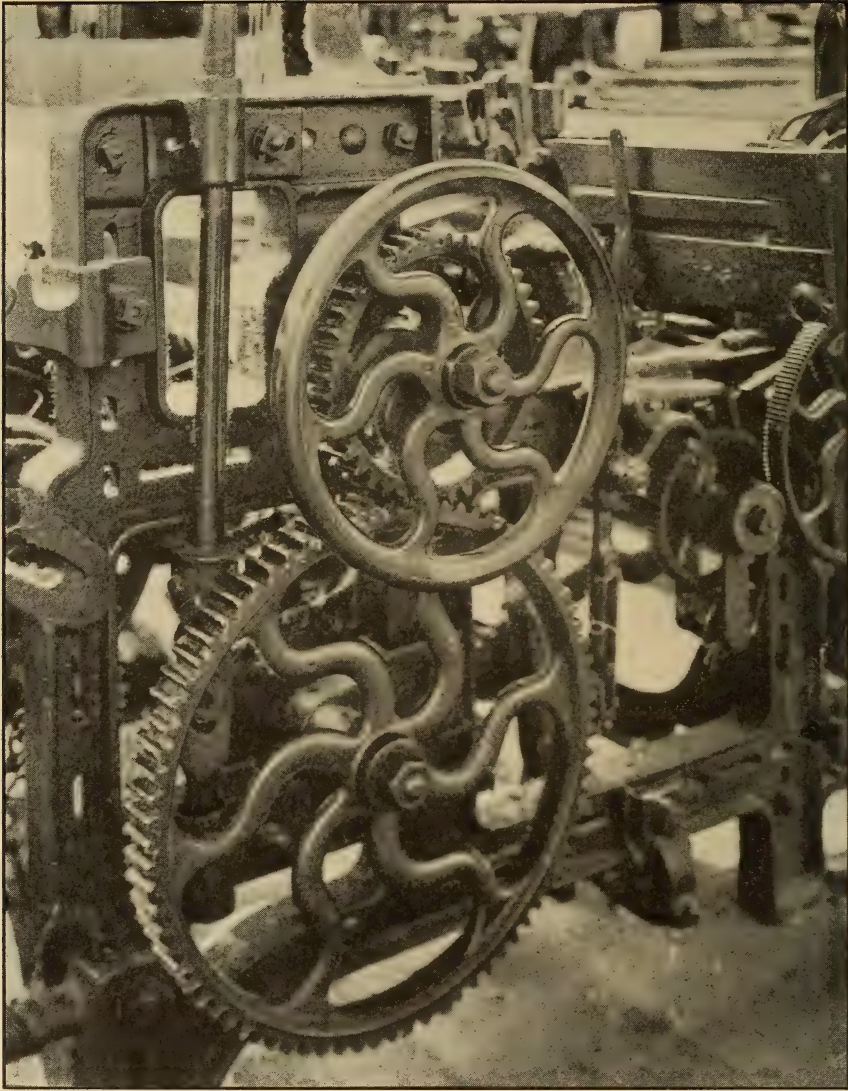


FIG. 16.—TAPPET AND CRANK COG-WHEELS WITH ARMED BALANCE WHEEL

the old and pulls the new thread through the eyelet. This, however, takes much time. When multiplied 500 times during a single day it affects the weekly earnings of the weaver very materially.

There are, however, shuttles now manufactured which preclude the necessity of "kissing" altogether. These are made for cops or pirns (Fig. 13), and are as efficient as ordinary shuttles with eyelets. They

are extensively used on the Continent and in Indian factories. The threading of these shuttles is essentially simple (Fig. 11), and is completed as speedily as by sucking the thread through eyelets. Fixing the cop in the shuttle is done precisely as with the ordinary type (Fig. 12).

Picking-sticks come within easy range of shuttles in the casualty list, but the injuries inflicted are less se-

vere. The bulk of trouble from picking-sticks comes from over-pick looms (Fig. 14), where the stick *A* is more exposed than that on an under-pick loom (Fig. 5). This picking-stick has a leather strap attached by means of a loose pin, which fits into certain apertures to regulate the length of the strap. The pins are continually vibrating with the action of the stick and become dislodged from their

apertures. If, then, the head or arm of the weaver be in close proximity, she may be severely struck with the smartly-swung stick. While the pin remains *in situ* the strap acts as a brake, preventing the stick swinging out of bounds, and the weaver is quite cognizant as to how far it will traverse. To prevent casualties from dislocated pins or from straps slipping off the pin-tops, the pins them-

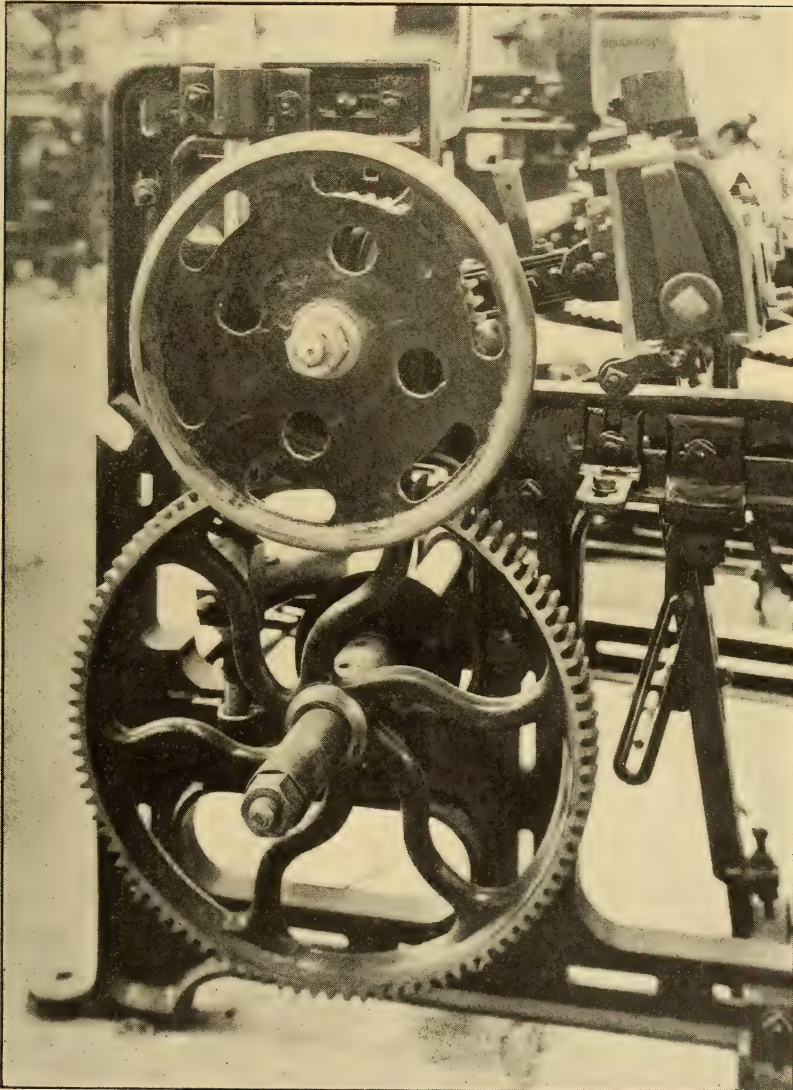


FIG. 17.—PLATE BALANCE WHEEL

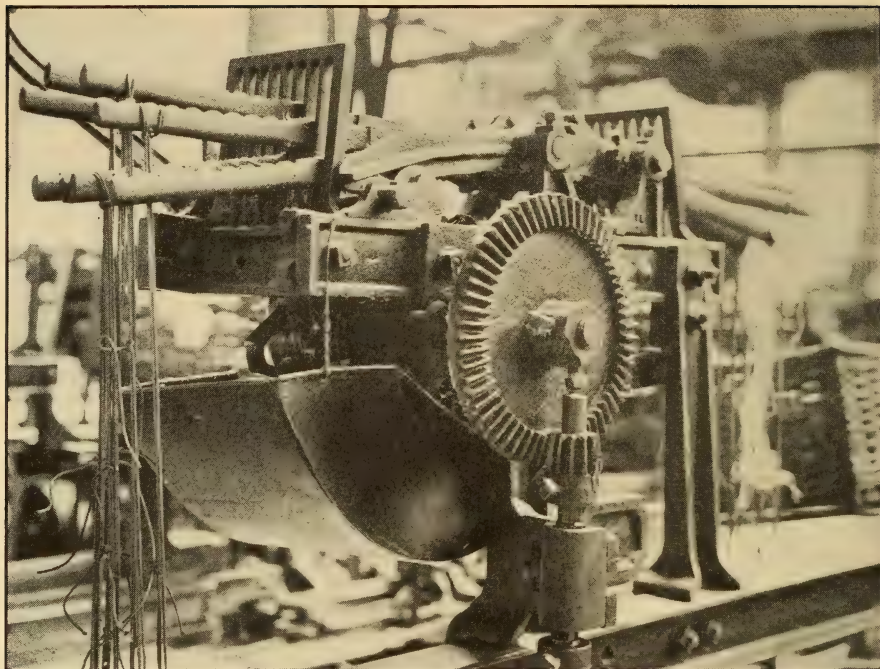


FIG. 18.—UPPER TAPPET PLATE WHEEL AND PINION

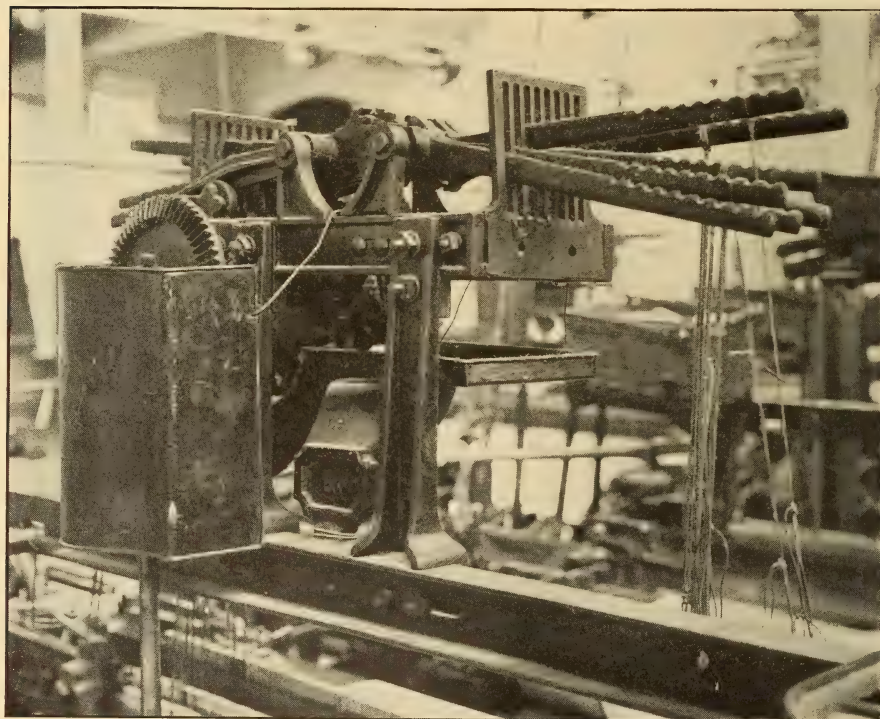


FIG. 19.—TIN-PLATE GUARD OVER UPPER TAPPET WHEEL AND PINION

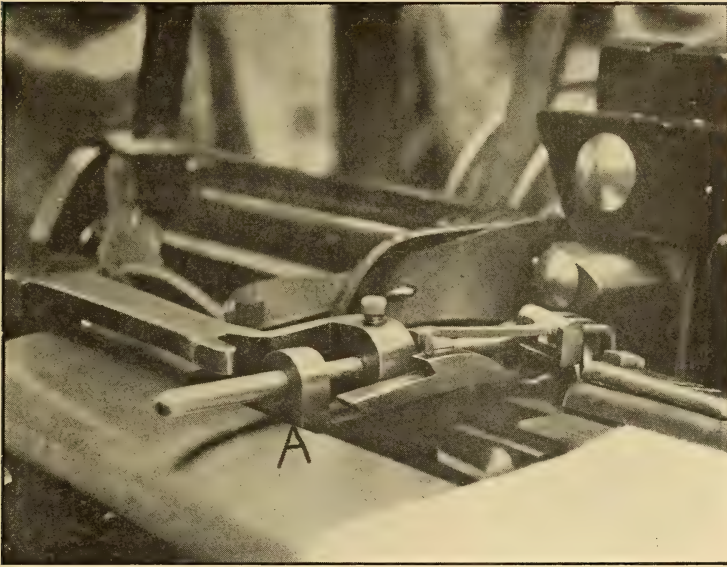


FIG. 20.—LOOM HAMMER (A) WITH LONG LIMB IN FRONT

selves are screwed into the picking-sticks or have round heads to prevent the strap slipping.

Toothed wheels on looms are still responsible for serious injuries, these generally resulting from the practice of cleaning the machines while running at full speed. Cleaning-waste is caught in the finely-cut teeth, and the weaver's hand, being entangled in the waste, is drawn to the intake of the wheels before the unwary victim can dislodge herself. But there are varying degrees of risk in different parts of the loom. The cog wheels operating the cloth-beams (Fig. 15), for instance, revolve at such a moderate pace as to be innocuous, and no special safety appliances are necessary. On the other hand, the tappet and crank wheels (Fig. 16) are fraught with considerable risk to weavers passing round looms or carrying boxes of weft along the factory alleys. These wheels revolve at 150 to 220 per minute and have a peripheral rate of motion of 12 feet per second. Clearly there is little chance of escape when a hand is seized by these wheels. How, then, shall we guard practically to eliminate this risk?

A balance wheel is seen in front of the tappet and crank wheels. This "balance" is frequently turned by hand in starting the machine, and, as it runs immediately before the intake

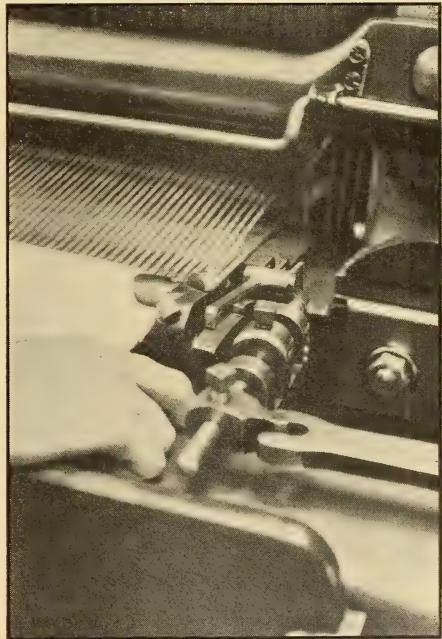


FIG. 21.—FINGERS TRAPPED BY LOOM-HAMMER AGAINST BREAST-PLATE

of the cogs, it acts as a partial guard. To further its efficiency in this respect the balance wheel is now manufactured as a plate wheel (Fig. 17) minus the spokes, which have wrought much damage by hurling hand-brushes at the operatives. A wrought-iron casing is also provided to cover the intake of the cogs, so that the risk here has been considerably mitigated. Upper tappet plate-wheels and pinions (Fig. 18) have a strange antipathy for weavers' hair, and many an innocent worker has been deprived of precious locks while piecing threads behind the loom. Ample casings (Fig. 19) are now provided for these bevels.

Hammers, frogs, duck-bills and heaters have an air of curiosity when referred to as parts of a loom. Yet every cotton loom contains one or other of these items. The hammer (Fig. 20) plays an important function in stopping the loom automatically when the weft breaks, and would seem innocent enough but for the fact of its coming so perilously

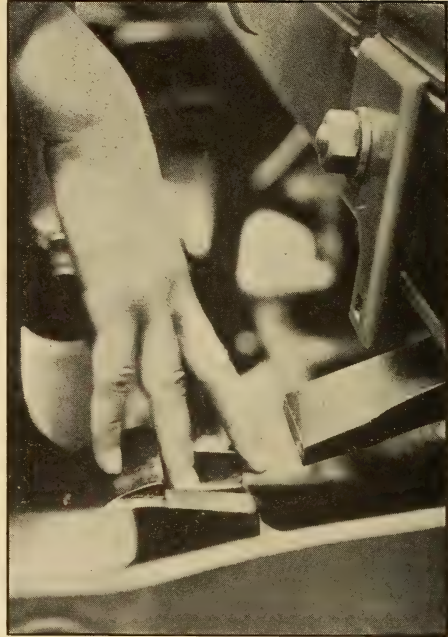


FIG. 22.—STOP-CATCH TRAPPING A FINGER AGAINST THE FROG

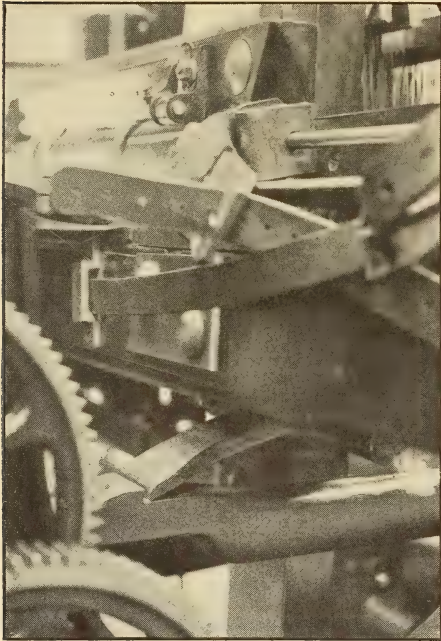


FIG. 23.—STOP-CATCH ON SHELF OF FROG

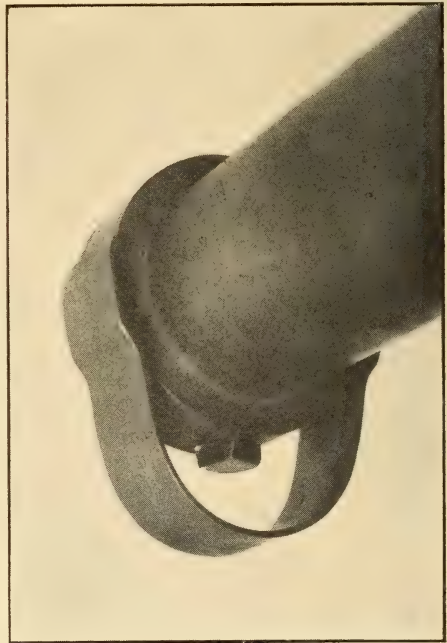


FIG. 25.—PATENT SPRING-CLIP OVER SCREW-HEAD

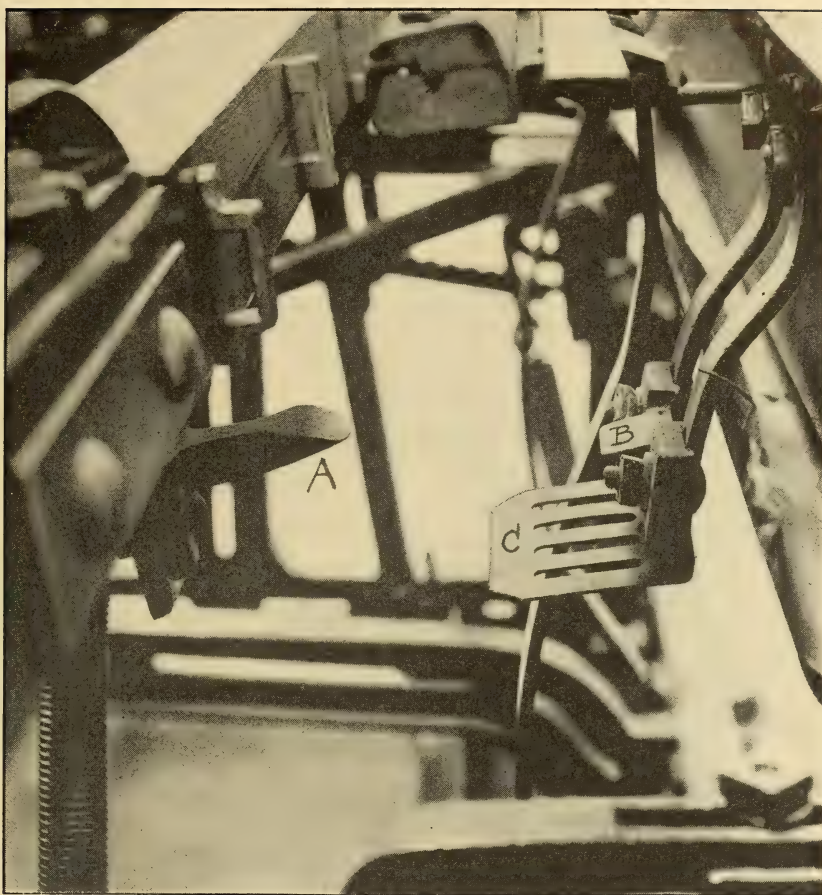


FIG. 24.—DUCK-BILL (A) HEATER (B) AND PROTECTING GRID (C)

near to the breastplate in its outward motion. If a weaver's fingers should be resting on the breastplate (Fig. 21), the front limb of the hammer, impelled by the force of the moving machine, will inflict severe injury. This may, however, be easily obviated either by raising the hammer so as to allow of finger-space beneath, or by cutting off a portion of the front limb, giving ample space between it and the breastplate. Both methods have been adopted with complete success.

The "frog" operates in connection with a stop-catch (Fig. 22), and also contributes to an immediate check when the weft-thread breaks. Unwary fingers, of young weavers espe-

cially, frequently plunge into this cavity to pick out loose cop-waste or remove "fly," which clogs the operations of the machine. If the stop-catch should trap a digit against the iron "frog" a severe crush is inevitable. The catch so adequately meets the shelf of the frog (Fig. 23) that no space remains for fingers. Protection is at hand by simple means; a plate of sheet iron is merely fixed over the frog to keep fingers from the traversing space of the stop-catch. The catch and frog are used on fast-reed looms, while the duck-bill and heater (Fig. 24) perform similar functions on loose-reed looms. Duck-bills inflict most serious injury to the hand of the

weaver while she is smoothing the cloth over the cloth-beam. If the hand is raised too high it is crushed by the duck-bill against the sharp edge of the heater. A protecting grid is now fixed just below the heater, so as to prevent the weaver's hand reaching the track of the traversing duck-bill.

types of loom bristle with these screw-heads, which become exceedingly treacherous during cleaning operations. To remedy these conditions headless screws have been tried with varying effect, the contention being, particularly in the case of heavy looms, that extreme vibration causes the screws to release their grip. But

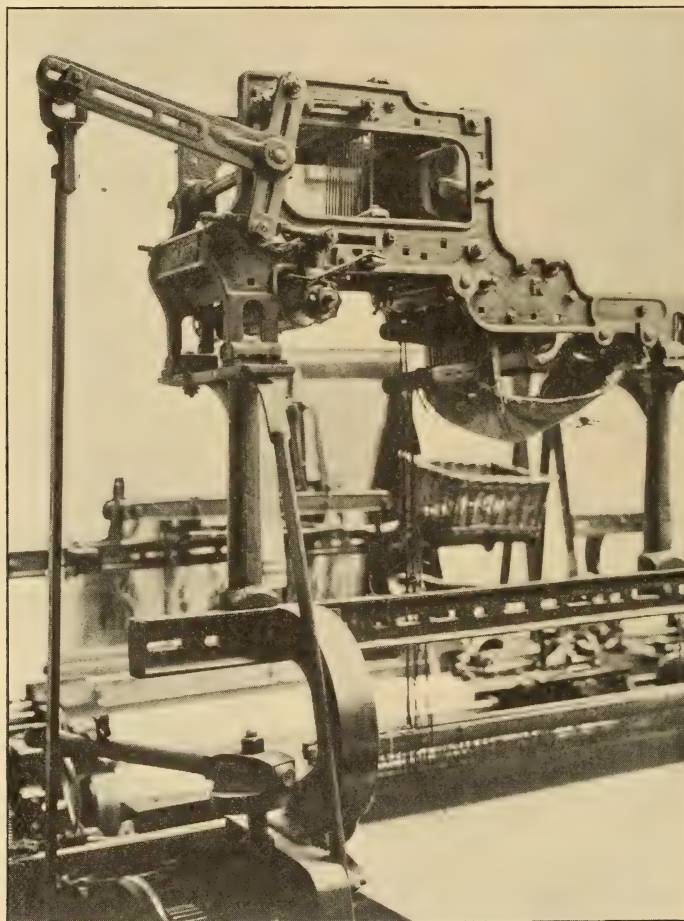


FIG. 26.—DOBBY APPLIANCE ON LOOM

A number of severe accidents occur in the weaving industry from projecting set-screws. Every week the story is told in the shed of one or another worker being cut or bruised by collision with a revolving screw-head, apparently hidden in some unsuspected part of the machine. Some

spring clips are now provided (Fig. 25), which allow the ordinary square-headed set-screws to be retained. The clip is slipped over the collar or shaft to which the screw is attached, and the screw-head is at once rendered harmless. No clothing or fingers of the operatives can approach

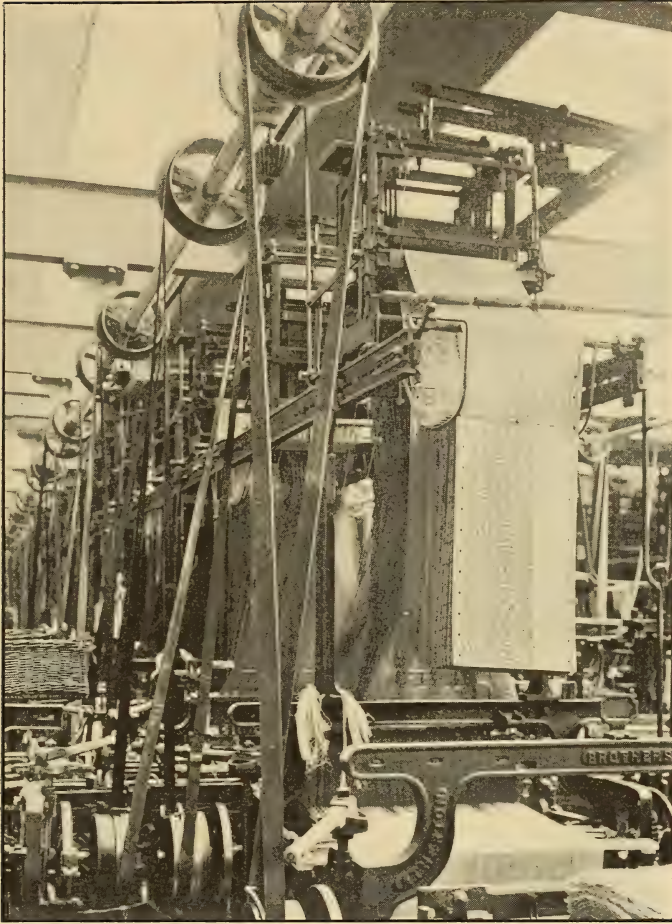


FIG. 27.—SERIES OF JACQUARD LOOMS

near enough to touch it. The clip holds to the shaft quite firmly and revolves with it.

The main driving pulleys and belts of looms are singularly immune from serious accident. This is largely accounted for by the fact that operatives are well aware of danger in approaching too near these factors, and by the wise provision on the part of machinists in erecting the driving parts of two adjacent looms close to each other. The risk is thus concentrated between the two looms, where there is no access or passage.

Looms are extremely varied in their build, function and incidence of danger. The broad sheeting looms

of 12 feet in width run slowly, their shuttles are heavy, the picks per minute are comparatively few, and danger is reduced to a minimum. Harking to the opposite extreme, we have 40-inch calico looms making over 250 picks per minute. From these, casualties are continually occurring. Speeds are fairly proportionate to length of reed-space. For instance, with looms devoted to "plain" as distinct from "fancy or ornamental" work, 32 inches in reed-space will allow 250 picks per minute; 44 inches in reed-space will allow 200 picks per minute; 56 inches in reed-space will allow 180 picks per minute; 66 inches in reed-space will allow 150 picks

per minute. In all weaving operations the casualty risk grows with the increased speed of the machine.

On a loom provided with a dobby appliance (Fig. 26) for fancy shedding the speeds are considerably reduced. Thus, a 32-inch loom will have 180 picks and a 44-inch loom will have 165 picks. Consequently, flying shuttles from dobbied looms are comparatively rare.

Jacquard looms (Fig. 27) are in the same category as regards rates of motion, and although considerably closer attention is required from the weaver than is called for on the plain loom, accidents seldom occur from their shuttles or wheels. The "flying shuttle" is, without doubt, the

gravest risk of the weaving shed; but seeing that, notwithstanding the addition to Lancashire alone of 20,000 looms during the past four years there has been no palpable increase in the annual number of casualties, it is obvious that, with the increasing efficiency of shuttle guards, shuttle-flying will approach nearer its quietus. It is even suggested from important engineering sources that, with the electrification of cotton mills, the shuttles of looms may be held entirely under control, and thus be prevented from plunging out of the machine. When that day dawns the weaving mills of Great Britain will be among the safest of all its hives of industry.



HIGH SPEEDS AND THEIR RELATION TO MODERN PRACTICE IN RAILWAY ALIGNMENT

By Charles F. Draper

IF one looks backward and compares the condition of things in the earlier days of railways with the state of progress reached to-day he would be venturesome indeed who would prophesy that we have reached a finality.

Unless revolutionary changes be made both in the haulage machinery and in the design of the track, one is, nevertheless, tempted to state that we have, in our more advanced railroads, approached closely to the maximum speeds that are safe.

The maximum speeds upon track considered as comparatively straight would appear to be governed by economical considerations. When, however, the question of speed limits on the straight is left for that dealing with safe speeds round curves, we approach a problem which is much more dominated by mechanical laws.

One might approach the latter in several ways. The best practice might be enunciated for the construction of new or the most suitable methods examined for the improvement of existing railways. In the former a minimum radius would be specified and thus end the argument. It is impracticable, however, to divert existing lines to the desired extent in many places where high speeds are required owing to the great expense. It thus becomes necessary to deal with the re-alignment of the dangerous portions within the available limits.

Many railways were constructed at a time when the speeds and other conditions prevalent to-day were not contemplated or even thought possible.

They are being gradually improved

with the relaying of the permanent way, using a heavier and better type of rail, improved fastenings, points and crossings of a better design, stronger and better sleepers and the substitution of a broken stone ballast.

But the most unwelcome portion, and no inconsiderable portion, of their inheritance from these earlier periods consists in the imperfect location and alignment of the roadbed itself.

The difficulties lie in the existence of sharp curves and steep grades. These defects undoubtedly exist to a greater extent on the branch lines and become serious matters on the development of such lines and when higher speeds are necessary over them to meet the requirements of the public.

It is related of a certain railway engineer that, when asked why he had constructed a tunnel on a particular section which appeared totally unnecessary, he replied that he wanted to have some of everything. This reason will also, perhaps, partly explain the existence of some of the sharp curves which embellished many of the earlier Parliamentary plans, which if they did not represent railway lines with a capacity for high speeds, were at least picturesque.

Such lines, however, sufficed for the needs of the times in which they were constructed; moreover, there is no doubt but that in many cases considerable economies had to be exercised on the part of those who were entrusted with their construction.

This is the condition of affairs, however, which has to be faced.

Many disastrous accidents have occurred owing to the running at excessive speed over sharp curves, and

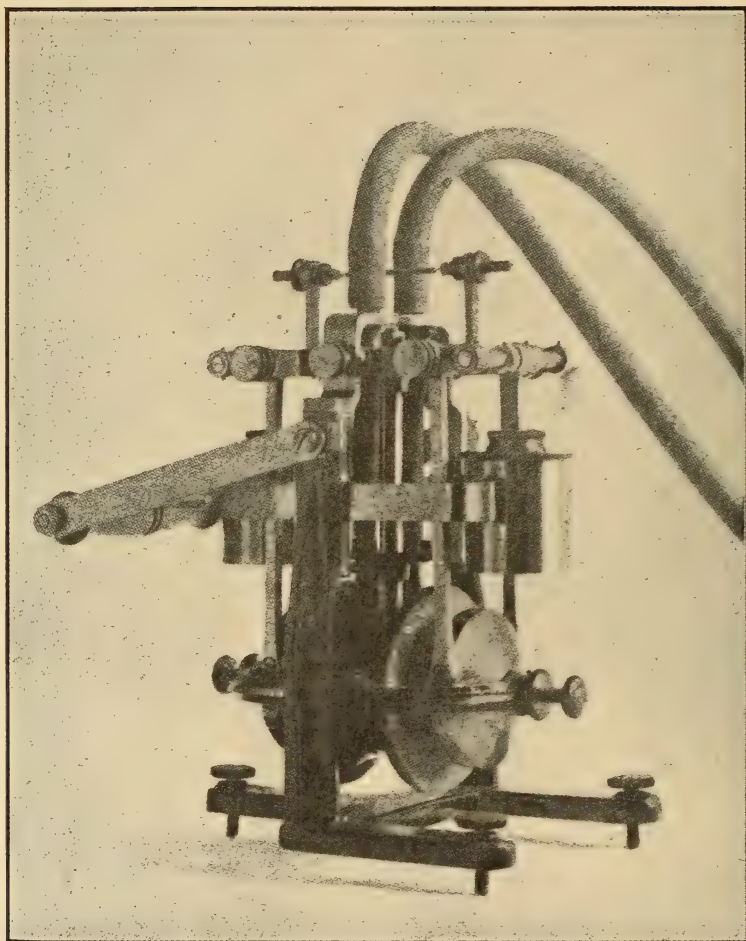


FIG. 1.—THE BALLISTIC PENDULUM

the attention of the public at large is thereby drawn to the limitations imposed upon speeds by the alignment of the track.

Even at moderate speeds a defective road will cause jolts and uncomfortable lurching of the coach, particularly in entering and leaving curves.

There are more exact methods than the passengers' sensations of measuring and recording track irregularities.

One of the instruments used for the purpose may be mentioned. It is known as a "Ballistic Recorder" and is the invention of M. Sabouret, engineer-in-chief to the Orleans Rail-

way. A transmitter and receiver, both being identical, are connected by a rubber pipe. Each consists of a brass drum closed by a rubber diaphragm. Any impulse given to the centre of the diaphragm of the transmitter is communicated by the enclosed air to the diaphragm of the receiver and there reproduced. A small brass plate is fixed to the middle of each diaphragm to facilitate making connections. The plate of the receiver carries a pen which records on a slip of paper the impulses received by the diaphragm. The paper is fitted to a cylinder which is made to rotate by clockwork. The working of the instrument is ar-

ranged by placing the diaphragm of the transmitter in contact with the bob of a pendulum placed in the compartment. All the irregular movements which affect the pendulum, owing to defects in the track, act on the diaphragm of the receiver, and are recorded on the paper. In order to prevent the slower oscillations of the pendulum due to centrifugal force, it has been provided with a glycerine brake, the invention of M. Dubois, which only permits the quicker oscillations to be recorded.

This method is also applicable for the purpose of recording the relative movement between different portions of rolling stock; for instance, the rotation of the bogie or the lateral displacements of an axle.

The accompanying illustrations show exterior views of the ballistic pendulum, as well as a section, and a general view of the recording apparatus is also given.

The systematic use of such an instrument in the inspection car would undoubtedly lead to the detection of faulty alignment and track defects generally.

With regard to the maximum speeds attainable, it may be of interest to mention the speed tests carried out in Germany between the years 1901 to 1903 on the line between Marienfelde and Zossen, a line

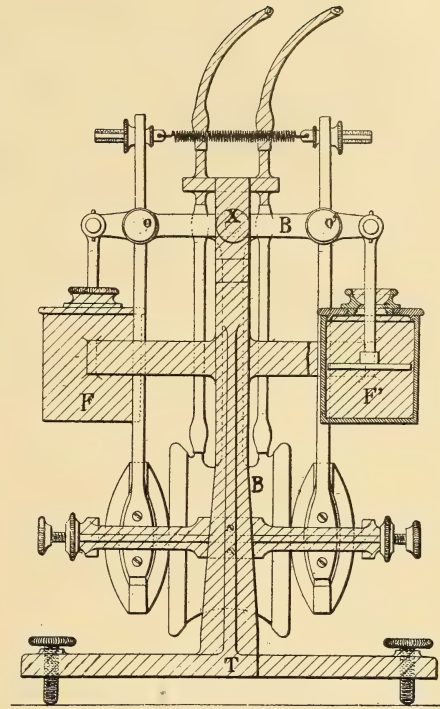


FIG. 2.—CROSS SECTION OF PENDULUM APPARATUS

worked electrically, the distance experimented over being about 14 miles long and the line being practically level and straight. Speeds up to 97 miles per hour were reached, when the tests had to be abandoned owing to the failure of the permanent way.

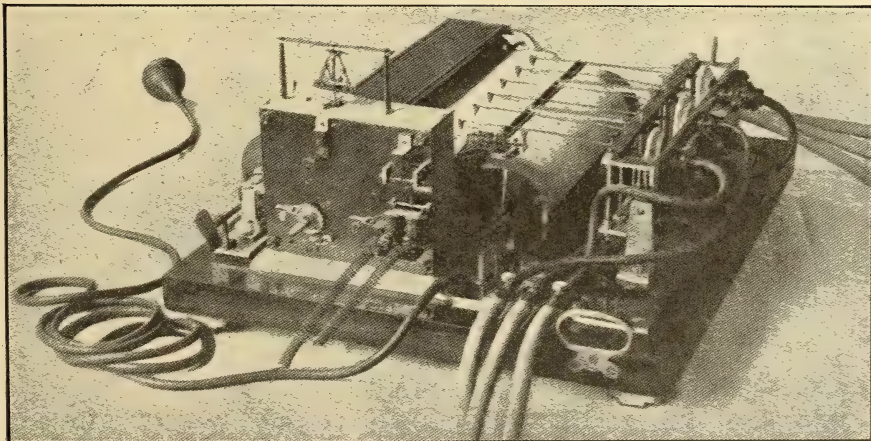


FIG. 3.—RECORDER FOR BALLISTIC PENDULUM

On the completion of the strengthening of the track a speed of 130.5 miles per hour was recorded in the latter end of 1903.

This appears to be the highest speed ever recorded on any railway. On special occasions the Philadelphia & Reading Railway, with their "Atlantic fliers," have averaged the speed of 81.3 miles per hour for a distance of 55.6 miles, while the speed of 100 miles per hour has been reached for single miles.

During a trial run on the Munich-Augsburg line, on the Bavarian State Railways, the locomotive hauled a train weighing 150 tons at a mean speed of 80.8 miles per hour. During a considerable time a speed of 96 miles per hour was attained. This is probably the highest speed ever recorded in Europe with a steam locomotive.

Numerous examples could be given of trains which require to travel at speeds between 70 and 80 miles per hour for portions of the journey in order to run to schedule.

Generally speaking the speed standard of the majority of railways has arisen almost insensibly, and one may reasonably assume that this state of things will continue.

The details of track construction have shown no radical change, and many railway engineers consider that the strengthening of the track is necessary in a greater degree from the increased density of traffic and consequent increase of wear than from the higher speeds of trains.

While 80 miles per hour may be regarded as a fair statement of the maximum speeds realized at the present time, it may be anticipated that at no very distant date this speed will be increased to 100 miles per hour, with a corresponding increase in average speeds.

When the railway line diverges from the straight or tangent and enters upon the curve, the question of speeds at once assumes a different aspect. Lateral forces which tend to disturb stability are brought into play

on entering the curve in obedience to the first law of motion as propounded by Newton.

During the passage of rolling stock over a curve there is a force which acts at the centre of gravity of the vehicle tending to thrust it outwards from the centre of the curve.

This lateral force is resisted by the action of the rail against the flanges of the wheels and remains constant while the velocity and radius are unchanged.

The case may be considered of a wagon with two fixed parallel axles. If this vehicle be pushed along a horizontal plane by a force acting in the direction of its length, it will move in a straight line.

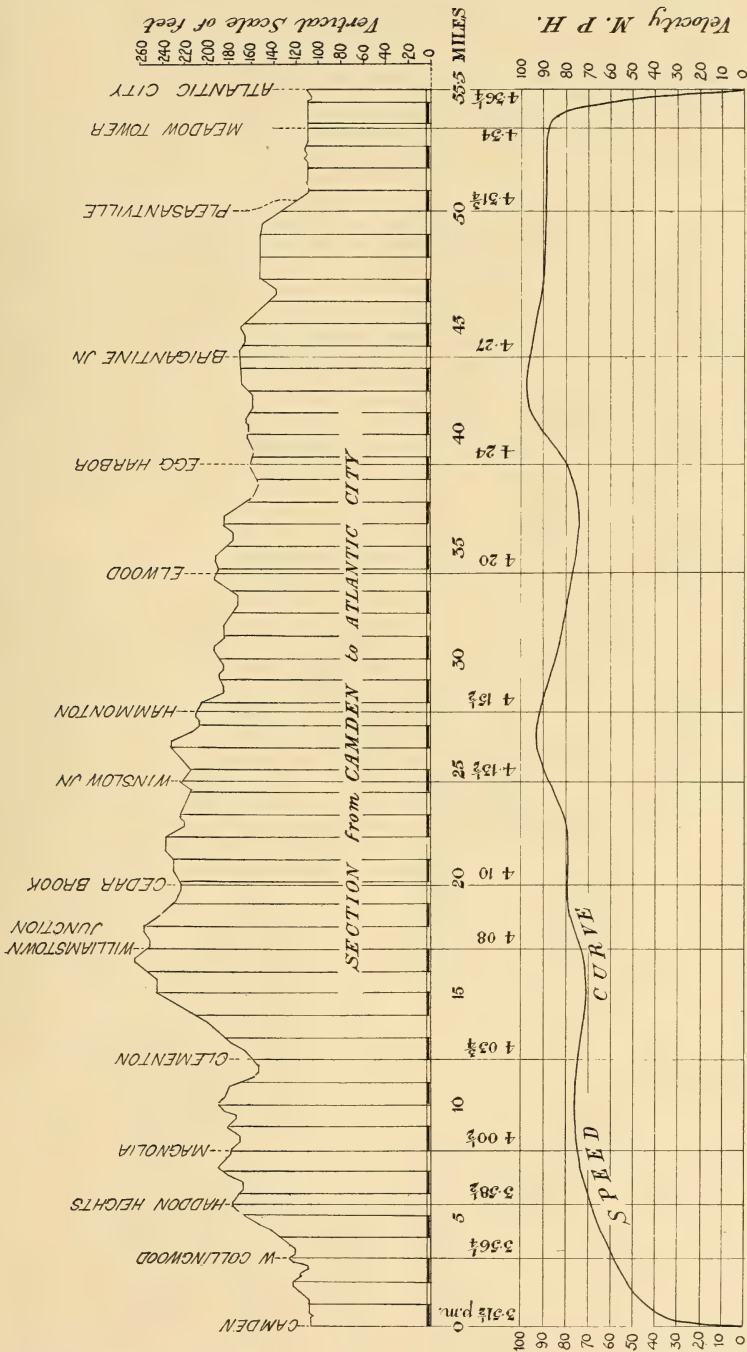
Assume now that one of the axles is fixed at a certain inclination to the other, and that the propelling force is constantly kept tangential to the path described, the path will be a circle. The radius of this circle will depend upon the wheelbase and the inclination of the axles. This radial axle is in effect the principle of the bogie frame. Strictly speaking, of course, the radius of the outer wheels should be greater than that of the inner wheels to avoid slipping, unless the wheels rotate on their axles, when the angular distance traversed by the outer wheels will be the greater.

If, however, the axles still be kept parallel, it will be found impossible to make the wagon follow a circular path unless by the exertion of a lateral force in addition to the tangential propelling force.

If a constant force act upon the leading outer wheel towards the centre of the curve, a circular path will result, but the motion will be accompanied by the slipping of the wheel on the rail if the wheels be keyed on their axles.

On a curved railway line this necessary lateral force is exerted by the rail-head acting against the flange of the wheel.

We have here, then, in essence



Train No. 25 August 1898: Max.^m Speed 96 m. p. h., Average 74.4

FIG. 4.—SPEED CURVE AND PROFILE OF THE READING RAILWAY LINE TO ATLANTIC CITY

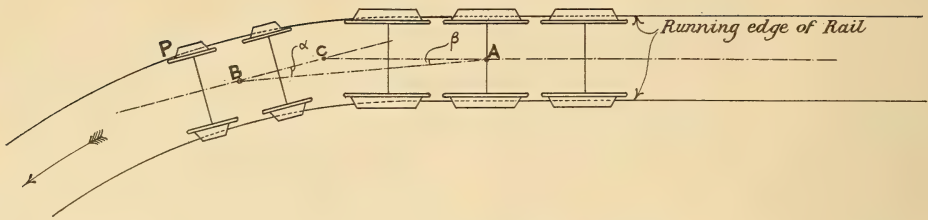


FIG. 5.—ENTRY OF A BOGIE ENGINE ON A CURVE

the two lateral forces which do not exist while running on the straight, that is, centrifugal force, and the force acting on the leading outer wheel, which may be termed the *steering force*.

To measure the extent of these forces is difficult, particularly in the case of the latter, and yet an accu-

ate estimate of both would appear to be necessary if the limits of speed are to be set down for running over curves.

Dealing with the former, the various forces brought into play are represented in the accompanying diagram, and by taking moments about the point B as representing the outer

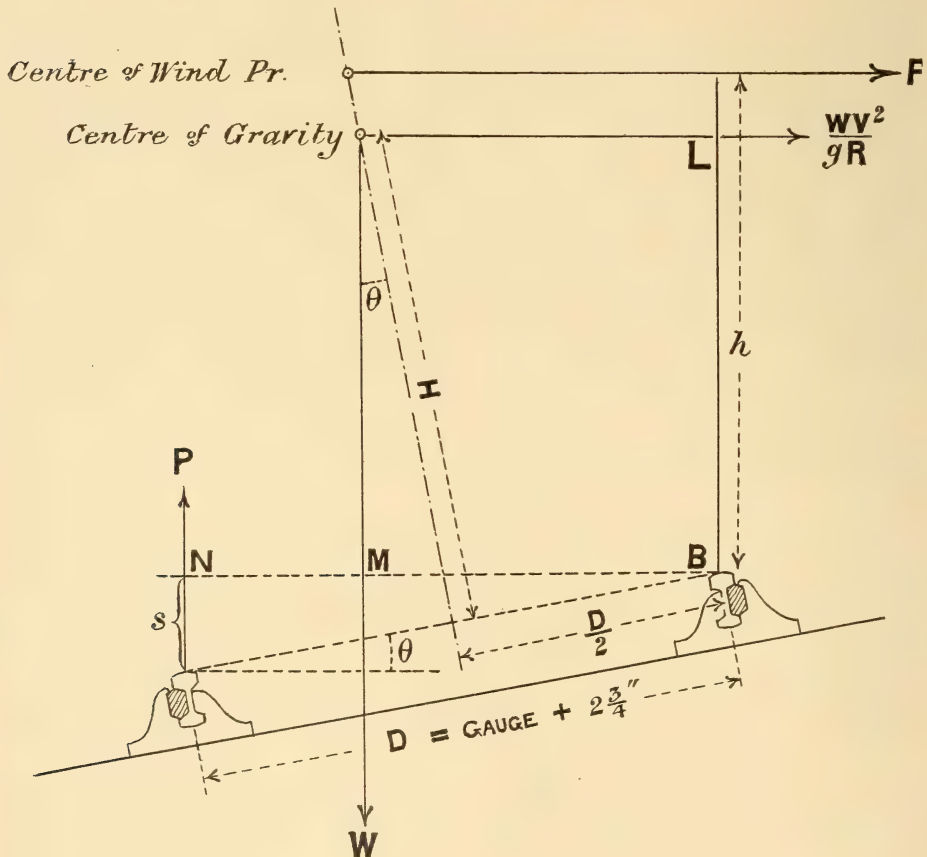


FIG. 6.—DIAGRAM OF STABILITY ON A CURVE

rail, we obtain the following general equation of stability:

tangent. Thus the force exerted by the rail on the wheel flange at P

$$P \times BN = W \times BM - \frac{WV^2}{gR} \times BL - F \times h$$

$$\text{i.e. } P D \cos \theta = W \left(H \sin \theta + \frac{D}{2} \cos \theta \right) - \frac{WV^2}{gR} \left(H \cos \theta - \frac{s}{2} \right) - Fh$$

Where W = weight of vehicle,

P = vertical reaction of inner rail,

F = horizontal force due to wind pressure,

R = radius of curve,

D = distance between centres of rails,

s = superelevation,

θ = inclination of plain of rails to horizon,

g = acceleration due to gravity,

H = height of centre of gravity of vehicle over rail level,

h = height of centre of gravity of wind pressure over rail level.

The critical velocity is obtained by equating $P = 0$,

$$V = \sqrt{\frac{gR}{W} \cdot \frac{W(2H \sin \theta + D \cos \theta) - Fh}{2H \cos \theta - s}}$$

or, neglecting wind pressure, the following simpler formula is obtained, which is independent of W ;

$$V = \sqrt{gR \cdot \frac{2H \sin \theta + D}{2H \cos \theta - s}}$$

From the above the critical velocities given on page 142 have been calculated.

A diagram is given which represents the entry of a bogie-engine on a curve. The bogie is shown wholly on the curve, while the leading driving wheels have just left the tangent. The points B and A represent the pivot of the bogie and the centre of the main frame, respectively, BC and CA being their longitudinal axes. The moment the bogie enters on the curve the wheel P crowds the rail and the bogie-frame is made to rotate. For its position on the curve represented, the bogie-frame has turned through the angle α relatively to the body of the engine BA , while the movement of translation of the pivot has caused the body to traverse the angle β relatively to the

has caused the bogie to rotate about its pivot, and similar action on both the outer wheels of the bogie has caused the body of the engine to slide transversely on its axles. The rotation of the bogie is opposed by the friction between wheel and rail, and that of the main frame by the frictional resistance to lateral slipping of the axles in the axle-boxes.

The magnitude of this steering force is difficult to calculate exactly, inasmuch as the slipping in each case is accompanied by rotation. It has been variously estimated as being between the limits of one per cent. and five per cent. of the total weight of the engine. Its precise amount varies, of course, with the wheel-base of the engine considered, and with the gauge of the road, as well as the values of the coefficients of friction assumed.

The total centrifugal force may be assumed to be divided equally between the bogie and the driving wheels, that is, that the leading outer wheel takes one quarter. We then have the following equation for the

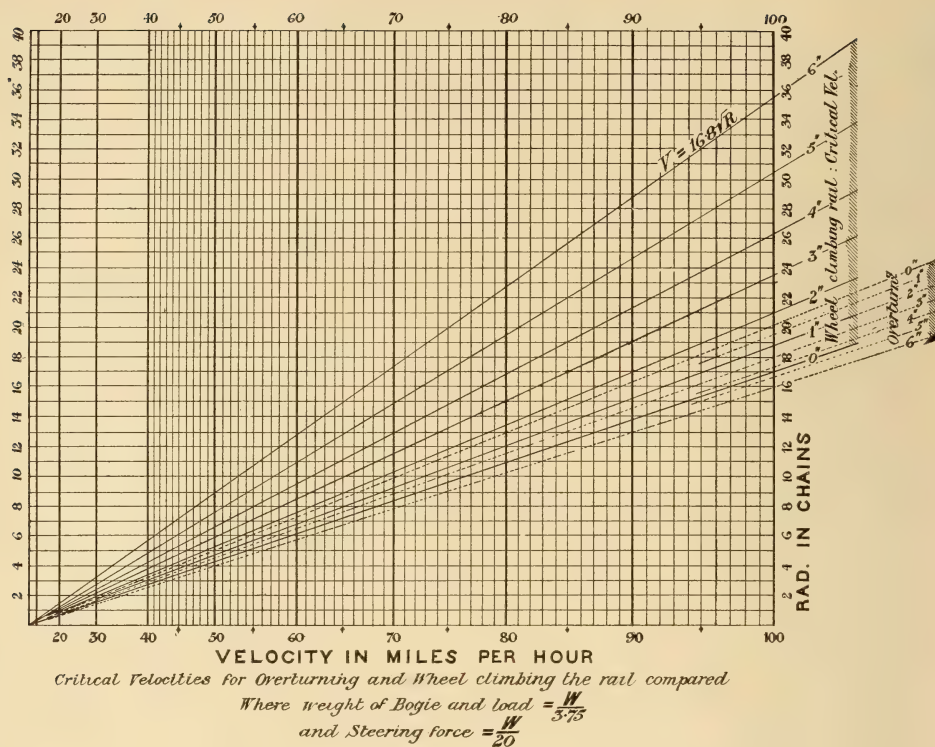


FIG. 7.—DIAGRAM OF CRITICAL VELOCITIES

total force with which the leading outer wheel impinges upon its rail:

$$F = \frac{WV^2}{4gR} + KW$$

where K is the coefficient, which when multiplied by the total weight of engine W gives the steering force.

It has been estimated by Mr. Spiller, in a paper recently read before the Institute of Civil Engineers, that if the total impinging force exceeds 1.36 times the weight on the wheel, derailment will ensue through the wheel climbing the rail. With this ratio adopted we are in a position to estimate approximately the critical velocity of derailment. The formula may be derived as follows:

$$1.36w = \frac{WV^2}{4gR} + KW$$

$$\text{or } V^2 = 4gR \left(1.36 \frac{w}{W} - K \right)$$

where w is the weight of one bogie wheel with its load. As the frac-

tion $\frac{w}{W}$ varies with the velocity, the

following correction may be inserted in the equation:

$$V^2 = 4gR \left[1.36 \frac{2}{x} \left(\frac{1}{2} + \frac{V^2}{gR} \right) - K \right]$$

$$\text{or } V^2 = 4gR \left(\frac{1.36 - Kx}{x - 10.88} \right),$$

in which the height of the centre of gravity has been assumed to equal the distance between centres of rails. The necessary correction for other heights can readily be inserted. The

coefficient $x = \frac{W}{w}$ when $V = 0$.

Reducing the velocity to miles per hour, this equation may be written:

$$V = 7.74 \sqrt{R \frac{1.36 - Kx}{x - 10.88}}$$

Correcting further for super-elevation, the formula may be written as follows:

$$V = 7.74 \sqrt{R \frac{1.36(1 - 4e) - Kx}{x - 10.88(1 - e)}}$$

where e is the ratio of the super-elevation to twice the distance between centre of rails.

A diagram is given in which the critical velocities of overturning and derailment are compared in the case of an engine in which x has been

assumed to be 15 and $K = \frac{1}{20}$. Fur-

ther tables can be readily constructed, substituting other values for these coefficients. The values adopted have been chosen as erring rather on the side of safety.

If the two formulæ giving the critical velocities for overturning and derailment are equated, we obtain a value for the super-elevation; for this value, namely, 1.2 inch, the two critical velocities are identical. If a greater super-elevation than this be provided, it would appear that the critical velocity of derailment would be reached before that of overturning. When nearing these critical velocities super-elevation would, therefore, appear to be rather a source of danger than otherwise.

In the above manner it is possible to examine the critical velocities for any specified engine and an approximate estimate of the danger limit arrived at.

It is generally agreed that a velocity ranging from ten to twelve times the square root of the radius in chains is safe for that curve. Trains are run daily at such speeds, and in some cases as high as fifteen times the square root of the radius. No curve, however, can be considered

safe for high speeds unless it be maintained in perfect alignment and is entered and left by a transition curve if its radius be small.

The case may be considered of an axle traversing a compound curve and passing from the circle of the larger to that of the smaller radius. While the axle remains on the larger circle, the centrifugal force remains constant. The moment, however, the axle passes over the point of contact between the two circles and then commences to travel along the smaller circle an increase in the outward thrust is developed, resulting in a shock to the rail and a corresponding shock to the axle, which is greater than the difference between the radii.

The same reasoning applies to the passage from a straight to a circle, the straight being a circle of infinite radius.

It is obvious, then, that if it can be so arranged that the variation in the centrifugal force shall be developed gradually and uniformly, smoother running will result.

The common practice in the past has been to "sweeten" the circle where it connects with the straight, which was in effect the introduction of a circle of somewhat greater radius in the region of the point of contact. The result of this, however, is to sharpen the radius of the imperfect compound curve so constructed near the point of contact between the two circles.

It has also been the practice to commence the tilting of the track at some distance before the curve is reached, in order that the full super-elevation required the instant the curve is reached may be gradually acquired.

This rate of "tailing out" the super-elevation varies in practice to a great extent, but it may be said, generally speaking, to lie between the limits of 1 in 300 to 1 in 700, or 1 inch in 25 feet to 1 inch in 60 feet.

Other engineers arrange that two-

thirds of the full super-elevation required shall be reached on the straight and the remaining one-third on the curve itself.

An objection to both of these methods of dealing with the super-elevation is that while the axle is on the straight it will be pressing against the inner rail, and on reaching the curve will be thrown against the outer rail, the result being a jolt varying according to the clearance between the flanges and the gauge at the point in question.

For the purpose of removing these defects in running, the transition curve is introduced, that is, a curve whose radius gradually decreases with the length of the curve traversed.

Since the super-elevation required at any point is inversely proportional to the radius of curvature at that point, the velocity being, of course, assumed constant throughout, it follows that in the transition curve the super-elevation can be "tailed out"

at a uniform rate, and at the same time the correct amount be given for every point in the curve.

In introducing a transition from a straight to a circle, the super-elevation is arranged to commence at the origin of the curve, where its radius is infinite, and to reach at a uniform rate its full amount at its contact with the circle.

In connecting the circles of different radii the super-elevation is uniformly graded between the two points of contact of the transition with the two circles.

The formula for such a curve is derived from the general formula for spirals:

$$\lambda = \mu \phi^n$$

where λ is the length of curve from origin, ϕ is the angle made by the tangent at any point with the axis, and μ is a constant.

If the radius of curvature at any point (ρ ϕ) is required to vary inversely as the length of curve from

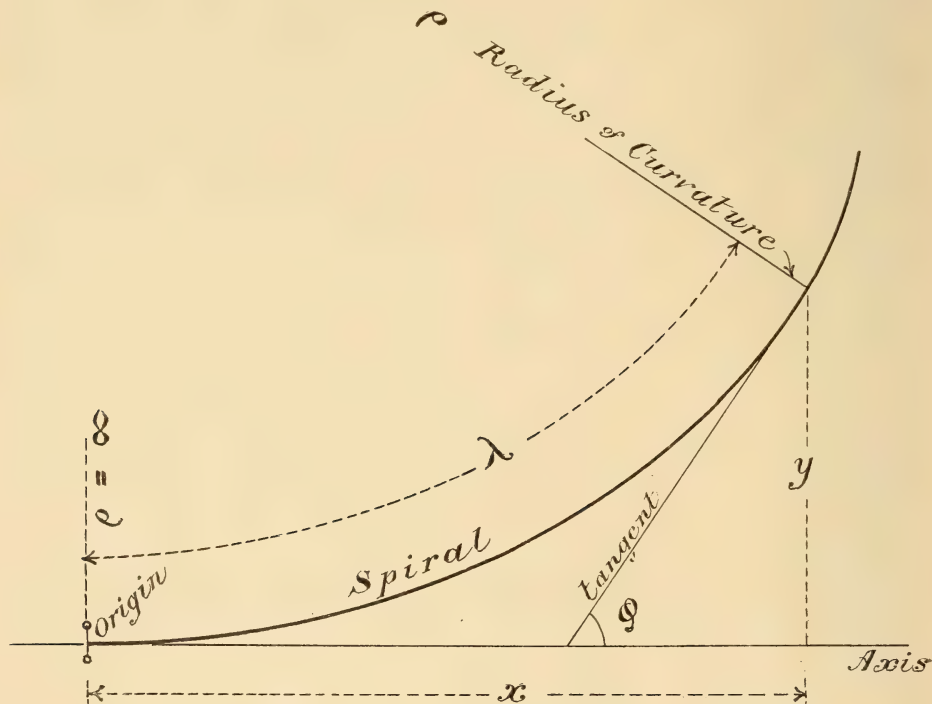


FIG. 8.—DIAGRAM OF SPIRAL CURVE

EQUATIONS OF CURVES

TRUE SPIRAL $\lambda = \mu \sqrt{q} = \sqrt{2RL} \sqrt{q} = 1089.954 \sqrt{q}$

CUBIC PARABOLA $y = \left(\frac{L}{3L^2}\right)x^3 - \left(\frac{L}{6RL}\right)x^3 - 0000002806x^3$

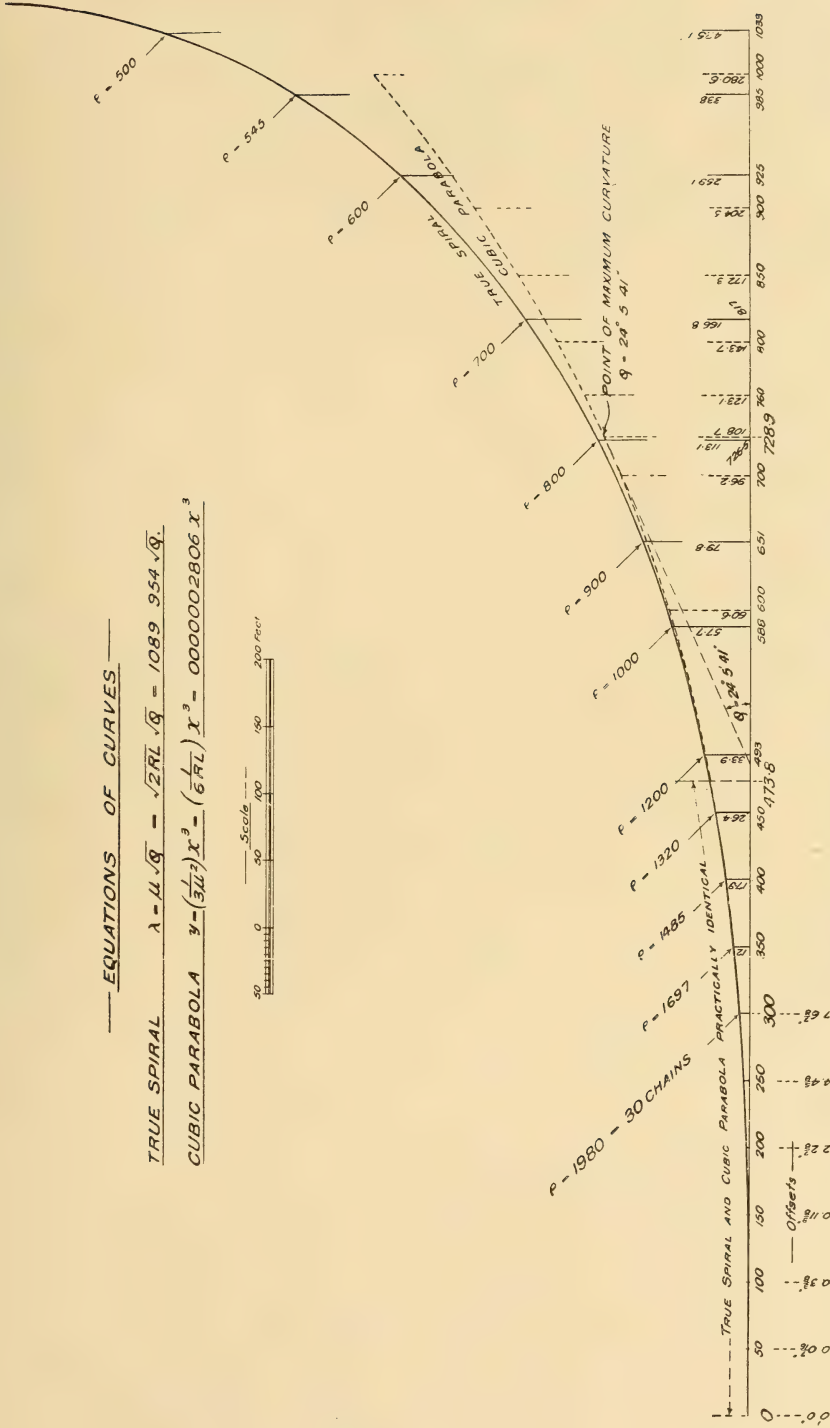


FIG. 9.—COMPARISON OF SPIRAL AND CUBIC PARABOLA

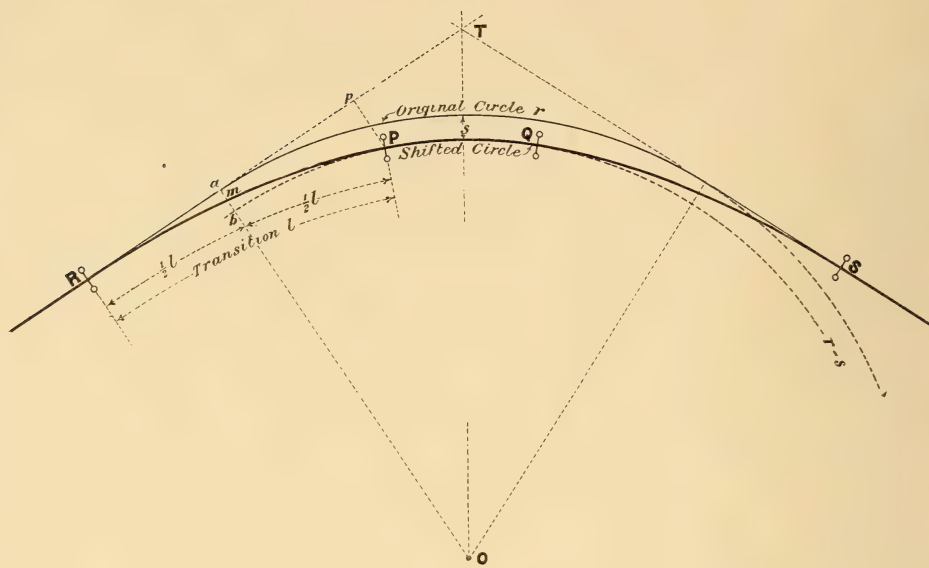


FIG. 10.—DIAGRAM OF SIMPLE CURVE

the origin to that point the equation is of the form:

$$\lambda = \mu \phi^{\frac{1}{2}}$$

and this may be called the "true spiral" for transition purposes.

On the diagram a portion of such a spiral has been plotted, giving a radius of 30 chains at a distance of 300 feet.

All other curves used for transition are approximations to this "true spiral," and tables have been published with the deflection angles calculated for the purpose of laying out the curve with varying degrees of accuracy.

For ordinary practice it will be found that relatively a short length of the curve will suffice to reach the radius of curvature required, and one of these approximating curves, which is commonly used, will be mentioned. This curve is known as the "cubic parabola."

The Cartesian equation is as follows:

$$y = \frac{1}{3\mu^2} x^3$$

The "true spiral" and the "cubic parabola" have been plotted, one over the other for comparison, and it will be seen how close they lie for a distance adjoining their common origin. They may be considered practically identical as far as .38 R, R being the radius of the circle to be approached.

It is important, however, to recognize the limitations of the cubic parabola. While its radius of curvature at the origin is infinite and decreases gradually, it reaches a point where the radius of curvature becomes a minimum and from that point begins to increase.

For all cubic parabolas the angle made by the tangent to the curve at this critical point with the axis is constant, being $= 24^\circ - 5' - 41''$ and, of course, as a transition curve it is worthless beyond this point.

Three typical cases are given, showing the introduction of the transition curve:

- (a) Simple curve.
- (b) Compound curve.
- (c) Reverse curve.
- (a) Simple circular curve.

It is assumed that both tangents are unaltered. The shifted circle

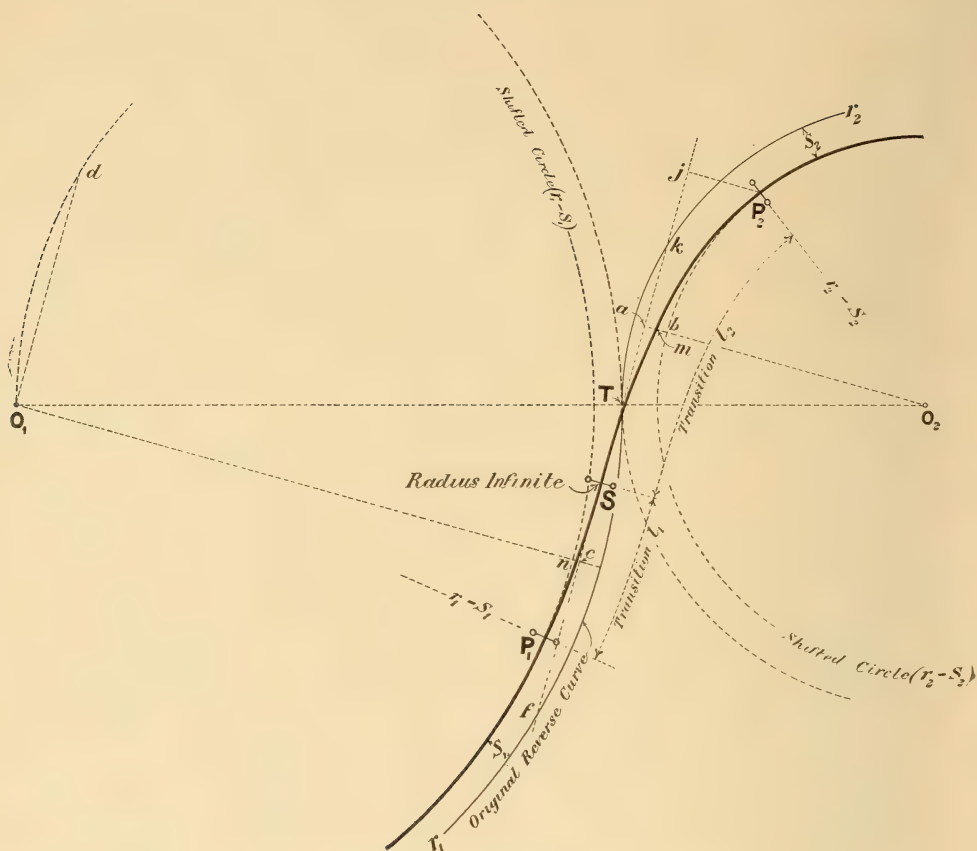


FIG. 12.—DIAGRAM OF REVERSE CURVE

from a , the point where the circle cuts the line joining the centres of the circles $o_1 o_2$. The line ab is thus the shortest distance between them.

The centre m of the line ab is also the centre of the transition $P_1 P_2$, which may be set out from the circle r_1 in the same manner as from the tangent in case (a). The points $p_1 P_1 m P_2 p_2$ will then lie on the altered curve.

(c) Reverse curve.

In this case the two circles r_1 and r_2 touch externally at T .

In the particular solution given, both radii are reduced, the shifted circles remaining concentric with the existing.

Two separate transitions are here necessary, having a common origin and axis. If e_1 and e_2 be the re-

quired super-elevations for the circles r_1 and r_2 respectively:

$$l_1 = k e_1 \text{ and } e_1 = m \frac{V^2}{r_1}$$

where k and m are constants,

$$\therefore l_1 = km \frac{V^2}{r_1}$$

$$\text{Similarly } l_2 = km \frac{V^2}{r_2}$$

Therefore, if l be the total length of transition desired, this length must be divided so that

$$\frac{l_1}{l_2} = \frac{r_2}{r_1}$$

On the line $o_1 o_2$ as diameter, de-

scribe a semi-circle and inflect from o_1 the chord $o_1 d$ such that

$$O_1 d = \frac{l}{2}$$

The common axis must then be parallel to $o_1 d$, and its exact position in the direction of a line perpendicular to itself may be varied within limits to suit the requirements of each case. Assuming it to pass through T cutting the circles in k and f .

Drawing the radii $o_1 c$ and $o_2 a$ perpendicular to $k f$, they bisect the chords $T f$ and $T k$ in c and a , so that we have:

$$f k = 2 c a = 2 o_1 d = l_1 + l_2$$

$$\text{Now } \frac{T c}{T a} = \frac{r_1}{r_2} \cdot T k = l_1, T f = l_2.$$

Set off the length $c S = \frac{l_1}{2}$, S is

now the required origin of the two transitions, which may be set out for each circle from the tangent $f k$, as described in (a).

In the foregoing three examples it is assumed that s is small compared with l .

With regard to the length of transition curves to be used, this may be derived in the following manner:

$$\frac{V^2}{R} \div \frac{L}{V} = \frac{V^3}{R L} = F.$$

Where F = acceleration gained in one second by an axle traversing the curve in foot and second units.

V = velocity in feet per second.

R = radius in feet of circle to be eased.

L = length in feet of transition curve.

$$\therefore L = \frac{V^3}{R F}, \text{ and if } F \text{ be restricted to}$$

$$\text{unity, we get } L = \frac{V^3}{R}.$$

Putting $V = 11 \sqrt{R}$, V being in miles per hour and R being in chains, $L = \sqrt{R}$ approximately.

This simple and convenient formula is, of course, rational only as long as the speed required over the curve to equal $11 \sqrt{R}$.

If, for instance, it be desired to lay out the curve for speeds not exceeding 70 miles per hour, the length of transition curve given by above formula would be excessive for curves of radius greater than 40 chains.

The correct length would then be determined by the formula:

$$L = \frac{V^3}{R} = \frac{253}{R}.$$

As regards super-elevation, the correct amount theoretically is that which will enable the weight of vehicles to be equally distributed over the inner and outer rails for the required speed. For the English gauge this amount is given by the formula:

$$s = \frac{V^2}{R} \cdot .06$$

When S is expressed in inches.

V is expressed in miles per hour.

R is expressed in chains.

It seems to be popularly believed that provided sufficient super-elevation be given, the curve is thereby safe for practically any speed. From the present article it will be seen that this is not the case. It must be remembered that the principal object of super-elevation is the comfort of the passengers, and has been stated earlier, for speeds in the critical region the provision of super-elevations may be a source of danger. It would, therefore, appear that unless the track can be improved up to the level of the required speed standard, speed restrictions must be imposed and rigidly enforced.

THE ELECTRIFICATION OF THE DETROIT RIVER TUNNEL

By James Cooke Mills

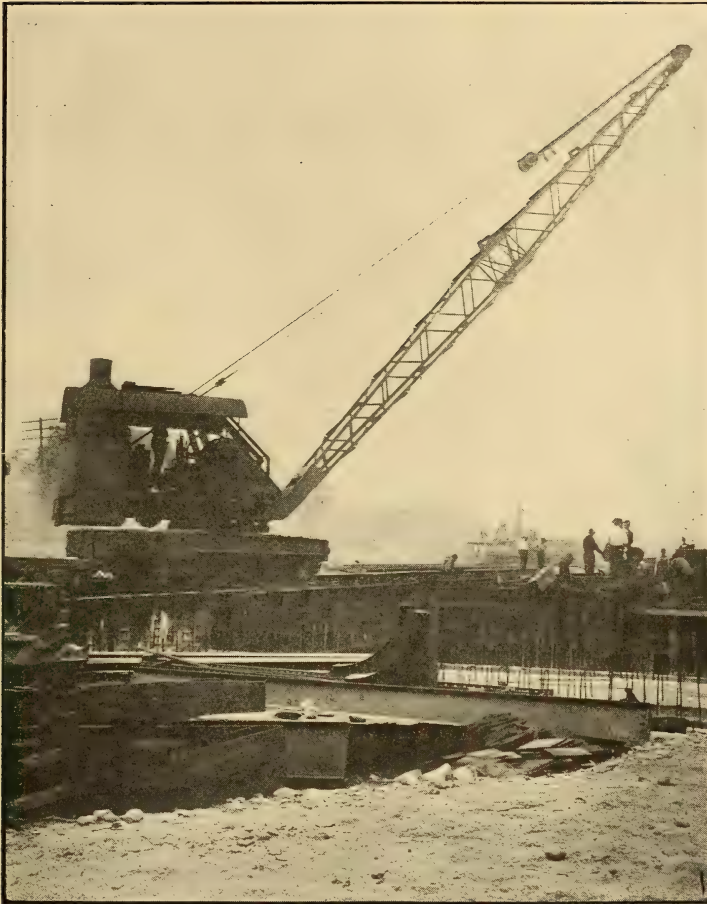
EVER since 1857, when the Great Western Railway of Canada completed its lines from Toronto and Buffalo to this strait connecting Lake Huron and Lake Erie, the hiatus of the swift stream has been more or less of a handicap to regular and prompt freight and passenger service. At first, for about fifteen years, when the obstacle to a free and uninterrupted service was perhaps little felt, the international commerce and some trans-continental traffic which sifted through Ontario was ferried across the border by breaking bulk and reloading in other cars on the other side. This was a slow, costly and wholly unsatisfactory expedient, but it was the best at that time devised. Bridging the straits by a high suspension bridge had been proposed and advocated by some engineers, but the necessary

legislation could never be obtained because of the bitter opposition of the vessel interests of the Great Lakes, whose position was well taken. The competition between the railroads running along the southern shore of Lake Erie and across lower Michigan, and also the cheaper water transportation, finally became so keen that the old system of package ferrying at Detroit was unprofitable.

By 1872 the volume of traffic across the Canadian border had increased to such an extent that other means of ferrying were resorted to, and the first steam transport, the Huron, was built and put in service by the Grand Trunk Railway. The transport took the cars, either of the freight or passenger service, on tracks running lengthways on its broad deck by having them switched from the dock over an adjusting



TRAIN FERRY ON DETROIT RIVER



LONG-ARM LOCOMOTIVE CRANE USED IN THE CONSTRUCTION OF DETROIT
RIVER TUNNEL

apron, ferried them across the river and had them re-switched to docks there. Since that time the ferry system has grown steadily, so that ten large and powerful steamers, some of which are equipped with ice crushers and additional propellers under the bows, have been required to handle the traffic of fully 25,000,000 tons and passengers numbering more than 2,000,000 yearly.

The time came about five years ago when even this system was no longer adequate to the ever-increasing traffic of the five trunk lines, and the Michigan Central, which is the second important tentacle of the New York Central Lines, undertook the

building of a double-tubed tunnel to connect its lines through Canada to Buffalo, Niagara Falls and Hamilton with those stretching westward to Chicago. After the incorporation of the Detroit River Tunnel Company, following necessary legislation by both the United States and Canada, a thorough organization was perfected by the advisory board of engineers, consisting of W. J. Wilgus, chairman, H. A. Carson, consulting engineer, and W. S. Kinnear, chief engineer. Benjamin Douglass was appointed assistant chief engineer in charge of construction. The preliminary work, such as drawing of plans and specifications, and drilling of test

holes in the bed of the river along the proposed site to determine the underlying strata formations, was at once started and had so far proceeded that contracts for construction of the tunnel were let to Butler Brothers of New York in July, 1906.

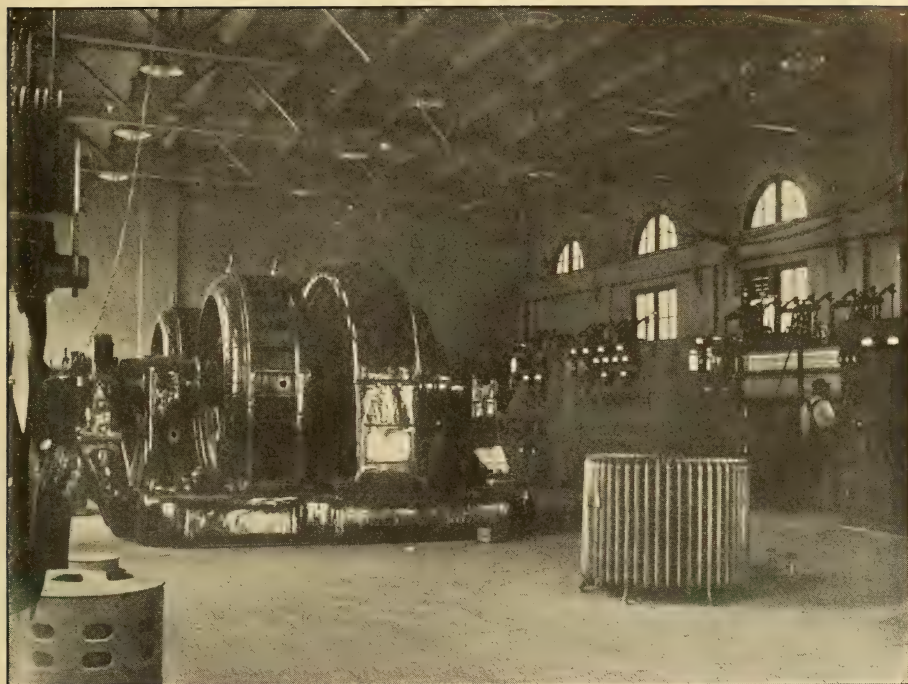
After four years of steady progress of the work, in which the highest engineering skill has been displayed, the tunnel is now completed, and a great volume of east and west-bound traffic has been turned through its twin tubes. No engineering work has been undertaken in the Middle West since the building of the Sault Ste. Marie canal and its immense locks, which is of such great economic value to transportation. The Detroit River Tunnel cuts off more than one-half hour from the schedules of fast limited and express trains between the East and the West, and effects a saving of from three to twelve hours in the case of through freights. It has reduced the cost of handling the immense traffic flowing across the border, at least 75 per

cent., and has retired the slow but spectacular ferry transports from service in the busy river.

But aside from the economic possibilities of the great tunnel, it is a notable engineering work, because of methods employed in its construction. It is different from all other tunnels, and none of the experience gained in previous tunnel work, as in drilling the rock and in forcing hydraulic-driven shields through the stiff blue clay of the river's bed, was of avail. The entire scheme of excavating a deep trench in the river bed and sinking therein a series of huge steel tubes, 260 feet long and 23½ feet in diameter, to form the waterproofing of the tunnel and also a means of conforming the inside rim of concrete two feet in thickness, which is the actual tunnel, was devised by Mr. Wilgus; and in the execution of the plans there was required more constant daring, more spectacular adroitness and more resourceful ingenuity than is usually demanded in such work. The construction plans and



A SECTION OF THE TUNNEL UNDER THE DETROIT RIVER



INTERIOR OF THE SUB-STATION, DETROIT SIDE

methods employed were quite fully described by me in an article which appeared in this magazine in December, 1907, but now that the remarkable tunnel has been completed there are features of the electrical installations and equipment and details of its operation which are of unusual interest.

In the general plan the tracks come out from the tunnel portals and reach the summit of the slopes exactly on a line with the main tracks of the Central. On the Detroit side this point is a little less than a mile from the river, while on the Windsor side it is about a quarter over the mile, due to the fact that the slope of the eastbound tube is a less gradient than the other. The eastbound traffic is much heavier than the westbound, the former taking $1\frac{1}{2}$ per cent. grade, while the latter traffic, comprising many empty cars, takes a two per cent. grade. The two curves in the tunnel are 2,600 feet in length with a maximum cur-

vature of two degrees. To provide for perfect drainage there are five sumps, one at each portal, one at each shaft on the river bank and one in the center of the subaqueous section of the tunnel. At each of these sumps there are duplicate pump units operated by electric motors and capable of discharging double the maximum volume of water which could enter the tunnel at the heaviest rainfall known in this region. Perfect ventilation in the tubes is provided for by the twin-shafts at either end of the subaqueous section. The trains running through each tube in one direction create strong currents of air, which are drawn in through the shafts and forced out at the portals. The tubes are well lighted with glow lamps placed every 20 feet and hooded against the direction of the trains so as not to blind the engineers.

The sub-station, which is located near the shafts on the Detroit water front, is the center of mechanical ac-

tivity for the whole tunnel system. It is here that the electrical energy for the movement of trains and the operation of auxiliary machinery is conserved and distributed to the network of third rails, which carry it to the electric locomotives in tunnel and switching yards. The long, brick structure, with its high, broad windows, was built in two sections, one of which contains the generating units and some small machinery, together with a long switchboard, while the other section, with two floors, holds the immense storage battery. The initial current is furnished by the Detroit Edison Company from their great power plant, at an economic rate, and transmitted to the sub-station through four cables running in underground conduits. The current commercially supplied is an alternating current at 4,400 volts, three-phase, and to convert it to a direct current at 650 volts suitable for tunnel traction two large converters of the usual type are employed. The continuous current generators, which are mounted on the same shaft as the alternating current motors, are of the M. P. C. type, class H, amperes 1,540 and speed 514, and of 1,000 kilowatts each.

The current supplied first goes by cables through electrically-operated oil switches to bare copper buses, separated by barriers of vitrified brick. From these buses the current is distributed to the various machines through other oil switches similarly operated, and goes to the third rail system through underground cables to the tunnel shaft and thence down to the rail connections. The cables and all other wiring are carried along conduits in the bench walls and connections are made at the Windsor shaft. There is a small spiral stairway running in a separate shaft about five feet in diameter between the shafts of each side of the river to afford communication with the tunnel tubes. A transformer is used for the small motors operating water pumps, fire pumps, blowers and heaters for battery room.

The storage battery is a most important part of the plant. It conserves the electrical energy when the load on the feed cables is light, or is surplus, so to speak, and discharges its accumulated energy when the draw on the cables is heavy. The switches from one to the other are regulated by a booster which, by a small one to regulate it, changes the charge to a discharge or the opposite as the load varies. It is thus clear that when several or all of the locomotives are at rest or drawing lightly of the direct and continuous current the energy not being used is not wasted, but is stored against the time, and it may be a moment later when nearly all of the locomotives will be running heavily and needing all the power available. It is a great economic feature and insures a uniform operation of trains in the tunnel and yards. It is also an economizer in reducing the power bills, since the minimum rate is based on the uniformity of the load on the feeders from the Edison plant. Although of costly installation it saves the investment in and operation of at least two additional generating units and the power required for them. Even at the low price of electric power in Detroit, which rendered the construction and equipment of an initial generating station for the tunnel impracticable, the electrical energy used continuously, 24 hours every day, month after month, amounts to a considerable outlay of expense. I should add that the regulating energy for the booster is from a transformer placed in the alternating current line entering the station, as it gives a more positive and a quicker action and holds it nearer to a normal load than if placed on the direct current line on the generating side. The battery will discharge at its full capacity 3,480 amperes an hour, or at the rate of 5,040 amperes for a period of 20 minutes.

All the pumps in the tunnel are under the complete control of the attendants in the sub-station, and to this end there are special buses with



ELECTRIC LOCOMOTIVE FOR THE DETROIT TUNNEL SERVICE

starting compensators through which the outside pumps are started. There are ten pumps installed for the discharge of the water from the five sumps. The several circuits supplying the arc lamps in both the Windsor and Detroit switching yards are controlled from the switchboard in the sub-station.

The electric locomotives here used are of an approved type and show the highest efficiency of any yet evolved for tunnel traction. Although somewhat less powerful, as indicated by the term horsepower, than those in use by the New York Central in and about New York City, they develop a much greater drawbar pull in relation to the electrical energy expended. This is after all the prime factor in the movement of heavy trains up a $1\frac{1}{2}$ per cent. grade nearly one and one-half miles in length. The measure of energy, as expressed by the term horsepower, runs to high figures, relatively speaking, when utilized in great speed,

hence the greatest efficiency in tunnel traction is not so much a matter of high indicated horsepower as of effective draw-bar pull. The maximum tonnage efficiency of these locomotives is 1,000, with a favorable tonnage of 900, but in order to haul the heaviest through trains unbroken across the border and rush them on to their terminal, two of the electric locomotives are coupled together by the usual system and one engineer controls the movements of the train. At an average speed of 20 miles an hour in the tunnel the passage from one summit to the other is made in about eight minutes. Live stock, dressed beef and other perishables, together with high-class merchandise are thus subjected to but slight delay in the transit of the borderland.

Each power unit consists of two independent trucks, each pair of driving wheels having a powerful motor of its own connected by spur gears, which are of proportions to develop their full efficiency. The

total weight of the locomotive, which is 100 tons, is thus carried on the four pairs of driving wheels of 48 inches diameter. The shoes, which bear against the under-surface of the third rail, are hung on both sides of the trucks near each end, and in addition to these there is an overhead shoe to transmit the power by charged wires where several gaps occur in the third rail system at the foot of the shafts in the tunnel. Within the spacious cab are the usual controlling devices, so arranged in duplicate at either end, but on opposite sides, that the engineer has every lever, every gauge and every indicator in easy reach and may be read at a glance of the eye. Besides the controller, by which is regulated the current supplied to the motors, to accelerate or reduce the speed and power of the locomotive, and the reverse, also near at hand, there are the air-brake levers, and above the window the switches for turning on and shutting off the electric head-

lights and signal lamps. In front are the volt meters for registering the current used, and air gauges for showing the pressure in the air tanks, located in each end of the hood, for use in the brake system. Above on the roof of the cab is a regulation engine bell, operated by a compressed air ringer, and an air whistle displaces the usual steam whistle. In the center space of the cab is a large air pump or compressor, operated by electric motors, to supply the air necessary in the operation of the air brakes throughout the train.

The engineers to run the electric locomotives were selected from the old and experienced men on the honor rolls of the company, and under special arrangement with the Brotherhood of Locomotive Engineers were given a thorough training by actual service in the handling of the locomotives. For it is held that all trains running through the tunnel should be under the guidance of trusty men long experienced in the



THE DANGER SIGNAL AND MARKING DEVICE USED BY FREIGHT TRAINS BEFORE ENTERING TUNNEL

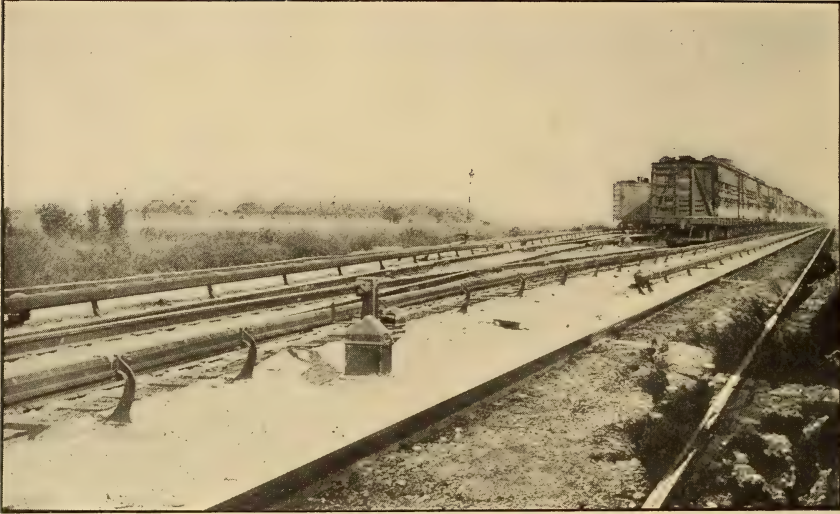


TRACKS AND THIRD-RAIL SUB-STATION, SHOWING POT-HEADS AND CROSSOVERS, WINDSOR SIDE, LOOKING EAST

careful handling of trains. The expert knowledge of electrical science, although desirable, is not regarded as a necessary qualification in the careful and proper running of such trains. There are rather those qualities of splendid daring and courage, instant decision and resourceful action with calm judgment, which characterize the engine drivers on the road, that are held as the most important considerations. Although one man controls all the movements of a train by the controlling devices within arm's reach of his station, there are always two men on the locomotive, as required by the inter-State Commerce laws.

The safety devices installed in the tunnel for the protection of life and treasure, and which render the passage of the tubes as free of danger as upon the surface, have been well planned and are most complete. The element of fire, as remote as the danger may seem at first thought, has been fully considered, and a six-inch water main runs through each tube

from portal to portal. At intervals of every 200 feet there are hose connections and reels of 100 feet of two-inch fire hose hung in the passageways between the tubes, so as to be convenient to both. These pipe lines are kept filled with water and ready for instant use. A complete fire alarm system, with boxes every 200 feet in each tube, is also installed. The simple breaking of a small glass gives an electric alarm warning to the attendants in the sub-station, who at once put the fire pump connecting the mains in action. The water system also provides a means of washing down the walls and bottom of the tunnel to keep them in a state of glistening whiteness. The waste runs off to the sumps and is pumped out at regular intervals. The benches, built of concrete, which afford a safe passageway for the trackmen and an exit from the tunnel, run along either side of the tubes, and their top with a width of $2\frac{1}{2}$ feet, are five feet above the rails. To reach them

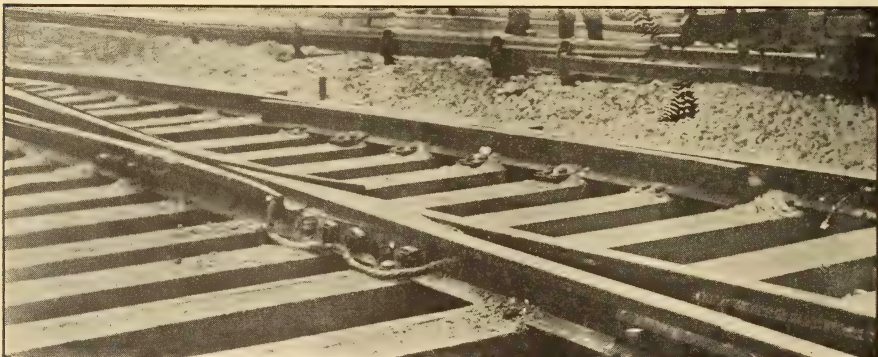


RAIL AND POT-HEAD CONSTRUCTION. WINDSOR YARD

from the rails there are iron ladders staggered every 25 feet in the walls and embedded flush in the concrete. Field telephones compactly built in metal boxes are placed at each portal and at the foot of the shafts for quick communication with the substation, from which connections are made with the city exchanges. Block signals for the safe operation of trains are placed 400 feet from the portals and at the summits. An arm at "caution" gives the right to advance to the next block, while an arm at "clear" gives the right to proceed to the summit of the slope on the other side. There is a con-

stant inspection of tracks and equipment to insure regular and fast service through the tunnel.

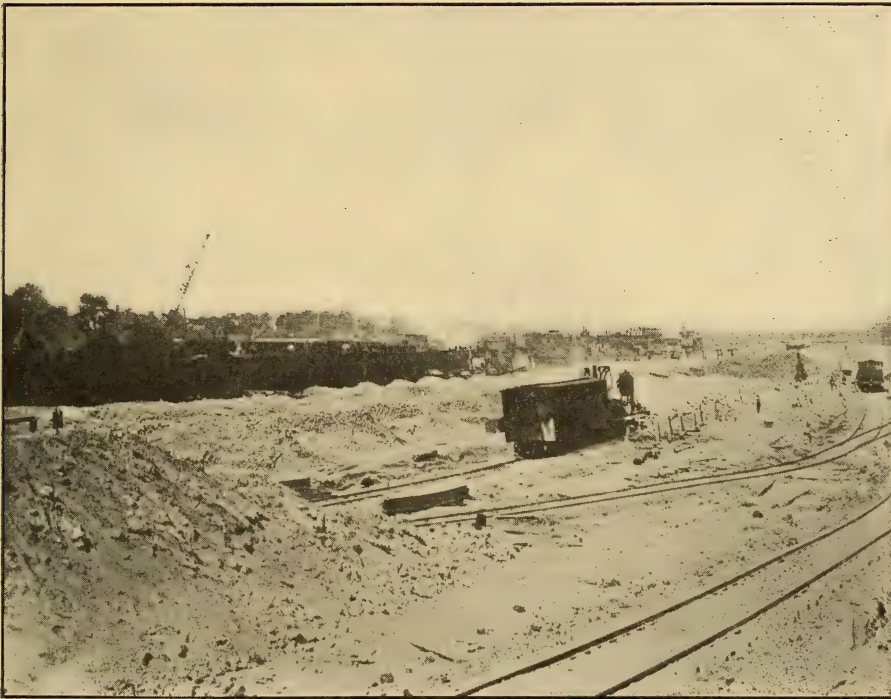
Since the summit of the western slope in the Detroit yards is $1\frac{1}{2}$ miles from the passenger terminal station on the water front, which location entails a switch-back with a loss of at least ten minutes to each through train, an immense passenger station, of such size as will easily accommodate all the railroads centering in Detroit, is being built adjacent to the tracks and a little beyond the summit. From a terminal point, Detroit will become a big way station, at least so far as the aspect of



BONDING OF MANGANESE STEEL FROGS BY WELDING

its railroad traffic impresses the traveler. The new station will be the largest, most conveniently-arranged and the most imposing of any in the Middle West, and all the trains of the Central, the Grand Trunk System, the Wabash, the Père Marquette, the Canadian Pacific, the branch of the Lake Shore and the Detroit, Toledo and Ironton will enter upon its tracks. The passenger switching yards and storage tracks to the west of the station will

rails, electric lighting and signal devices for electric traction. The bonding of rails and frogs was done by a welding process and the potheads at switches and crossovers and the covering to the third rails are of a type approved by electrical authorities. A safety device to protect the third rails from projecting parts on car trucks is installed in the outer yard, by which the projection hits a swing near the ground, receives a daub of white paint and at the same time in



SITE OF NEW PASSENGER STATION IN DETROIT

be electrified so that all movements of trains and cars will be by that power.

On the Windsor side the tunnel slope comes out in the old freight yard, and it was necessary to move or build a new switching yard a mile to the east. In laying out the yard the main line tracks were moved over to the south about 100 yards, for a distance of about a mile, in order to eliminate a curve. The new yard is completed and equipped with third

turning away the device rings an alarm bell in a watchman's shanty nearby. He telephones the number of the car to the yardmaster's office and the car is altered or thrown out of the train. The tunnel, switching yards and new passenger station will cost, when the work is completed and the accounts audited, a sum total not far from twenty millions. The expenditure is fully justified, however, by the ever-increasing commerce of the Great Lakes country.

SHEET PILING

By Ewing Matheson, M. Inst. C. E.

THE articles by Mr. J. F. Springer in *CASSIER'S MAGAZINE*, and especially that in the August issue, referring to applications of this system in Germany, show one more of the many useful purposes for which rolled steel is suitable. It may, however, be interesting to note that sheet piling of cast iron was used more than fifty years ago, and the methods employed and the experience then gained may be of use, now that the stronger and tougher material is available. On the other hand, just as cast iron was employed in preference to wrought iron because of its supposed less liability to corrosion, this same question is likely to arise in regard to steel. It may be historically interesting to reprint here the particulars given by the present writer in a book entitled "Works in Iron," published by him in London and New York in 1873 and a second edition in 1876.

COFFERDAMS AND ENCLOSURES

Cofferdams are watertight enclosures used during the building of foundations in water. The ordinary cofferdam consists of one, two or three rows of timber-piling rising above high-water mark and bolted transversely together, the space between the rows being filled with clay. Within an enclosure so formed excavations can be made and foundations built.

Iron has been used in direct imitation of a wooden cofferdam on the river Thames and elsewhere. Figs. 1 and 2 illustrate the method introduced by Mr. Joseph Phillips, of London, who, in his patent specification dated January 30, 1864, No. 258, describes the method as follows:

"My invention has for its object to render more or less perfectly watertight the vertical joints, in-

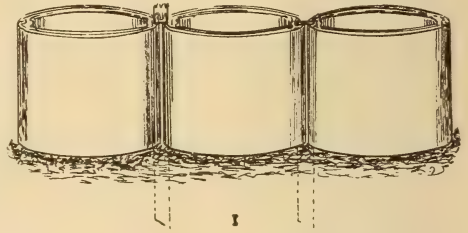


FIG. 1.—THE PHILLIPS COFFERDAM

terstices or spaces existing between metal piles or cylinders employed for structures that are wholly or partially under water and consist in forming grooves, recesses, shoulders or flanges upon the contiguous sides of such piles and then inserting into such grooves or recesses, or against such

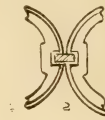


FIG. 2.—JOINT IN COFFERDAM

shoulders or flanges, pieces of wood or other suitable material, so formed that the pressure of the water causes them to fit tightly against one or more surfaces of the grooves, recesses, shoulders or flanges of two contiguous piles or cylinders, and thereby to prevent the water from penetrating through the joints, interstices or spaces between the two piles to the back of the same. I prefer to make the grooves in the piles and the pieces of wood to be inserted of a rectangular form, and I form the lower extremity of the

piece of wood with a double incline, so that, when driven into the ground in the same grooves, it is made of itself to press against the back surfaces of the two grooves and the side surface of one of them."

This method of keeping out the water was used in connection with the construction of the Thames Embankment between Waterloo Bridge and Charing Cross after the preceding portion of the embankment between Blackfriars and Waterloo had been constructed with an ordinary cofferdam, formed of two walls of timber piles with clay between. Oval tubes or caissons of wrought iron, made of plates and L-irons in the same way as iron boilers, were forced down into the river bed by dead weight, and timber piles were then driven into the spaces between, in the manner described above. Behind the wall formed by a series of tubes the area needed for the foundation of the embankment was excavated. The daily range of tide is about 17 feet, and at high water there was a considerable pressure inwards of the water from the river, and the shape of the tubes enabled them to resist with little assistance from timber struts behind. The permanent granite wall of the embankment having been built, the upper portions of the wooden piles and iron tubes were removed and were available for use for another length of wall.

In comparing this plan with the ordinary wooden cofferdam the superiority of one over the other depends entirely on the circumstances of each particular case. If timber can be readily procured at a moderate cost, there may be no advantage in using the iron. If, however, timber is expensive, and the extent of the works permits the same set of caissons to be used two, three or more times, it may be found expedient to adopt them. If required, the soil within them can be cleared out and concrete placed within so as to make a permanent wall with an iron face. Or if, as already de-

scribed, they are used for a cofferdam during the construction of a masonry wall, the lower portion of each tube may be filled with concrete and left in the river bed to act as an abutment or foot for the masonry. Caissons of the Phillips type were used also for the piers of the large railway bridge over the Mersey at Runcorn.

In water of moderate depth, the necessity for a watertight cofferdam has been avoided by the use of cast-iron plates, or sheet piling round the side of an intended pier.

In the construction of the new Westminster Bridge (1855-60) the engineer, Mr. Thomas Page, enclosed the spaces for the piers by a series of iron piles and plates, arranged so as to form a complete box or chamber. Cast-iron columns or piles *B*, 15 feet long and 15 inches diameter, were driven by an ordinary pile engine into the river bed at intervals of 7 feet, and in the spaces between the piles cast-iron plates *C*, 1¼ inches thick, were driven, the plates fitting into grooves in the columns, as shown in the illustration. The plates were stiffened by vertical ribs *b, b b*, and on the top by a flange. Above the plates the walls of the chamber were built up higher by stone, but this was a special arrangement suited to the occasion, and there is no reason why a greater depth should not be enclosed by iron alone. The chamber or caisson thus

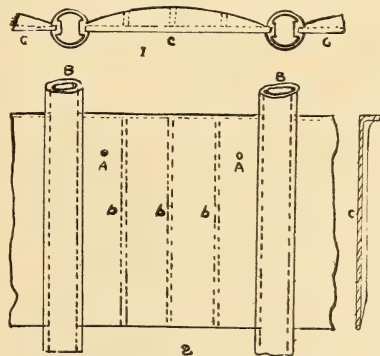


FIG. 3.—PAGE SHEET PILING

constructed could not be called a cofferdam in the ordinary sense of the term, because it was not made watertight, but was used only to enclose the area of the bridge pier, which was to be excavated and filled with concrete. When the piles and plates had been driven down to a sufficient depth the mud and shingle

a uniform thickness of $1\frac{1}{2}$ inches being maintained at the edges by means of the fillets *A*. The rib *B*, of fish-bellied form, was 8 inches deep at the centre, and, to counteract the tendency this form has to force the piles outward, the lower part of the rib was made in steps and the cutting edge of the toe was one-sided.

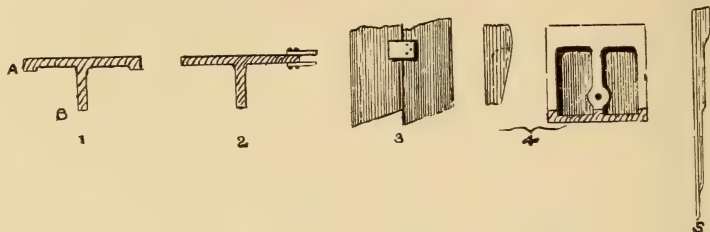


FIG. 4.—SHEET PILING AT THE LOWESTOFT HARBOUR

were dredged from within, and groups of wooden piles were driven into the hard clay below. Concrete made with Portland cement was then deposited on the piles, where it hardened under water, and, when the mass of concrete reached a point rather below low-water level, the masonry piers were commenced. To provide against pressure outwards, which might be caused by swelling of the concrete, tie-rods across the caisson held the plates together.

Any novelty there might be in the use of cast-iron piles, as described, consisted in their application for a bridge pier; but sheet piling for a permanent wharf, on an almost similar system of cast-iron columns and plates, had been adopted many years previously at Deptford, Blackwell, and elsewhere on the Thames.

Cast-iron sheet piles were used by the late Sir William Cubitt, engineer, for protecting the sides of the harbour constructed by him at Lowestoft in 1832. In this case a wall more than 1,000 feet long was formed of cast-iron piles of the section shown in the first illustration. Many experiments were made to obtain the best form of pile, and finally they were cast 30 feet long, 18 inches wide, and of a thickness greater at the centre than at the ends,

The piles were driven close together, edge to edge, clamps of wrought iron, $5 \times 4 \times \frac{3}{4}$ inches, being riveted to the sides to act as guides. The heads of the piles were thickened out to 3 inches and were strengthened by ribs, tie-bolts being provided for tying the piles to a horizontal oak-wall behind.

The piles were driven into the seabed by an ordinary pile engine, and it was found that, by using a very heavy weight and a thin piece of elm-wood on the pile head to receive the blow, few of the castings were cracked or broken. The piles were driven 10 or 12 feet into the seabed—here principally sand and shingle—with about the same depth of water above. The iron piling was found sufficient to retain the shingle of the beach behind without concrete, masonry or any other wall. Iron was used in this case as a substitute for timber, which would have been destroyed by the teredo worm; but it was supposed, by some engineers that the iron would become softened by the action of the water. After having been in place for forty years, it is found, however, that the iron has deteriorated only slightly at the edge of the pile, at places where the foundry “runners” have been broken off, and where the original

skin of the casting had been removed.

Another method of applying iron sheet piling has been tried with success by Mr. S. W. Leach, the engineer of the Thames Conservancy Board, in the construction of a lock near Oxford without stopping the navigation. In this case a certain portion of the river banks had to be enclosed while the side walls of the lock were being built, and a cofferdam or any ordinary arrangement of timber would have encroached too much on a channel only 18 feet wide, the barges passing through being 17 feet wide. A cross-section of the canal is shown in the illustration, the space to be excavated and the walls to be built being shown by the dotted lines at each side. The excavations having been performed by dredging, sheet piles of cast iron, as represented by the lines *AA*, *BB*, were driven down into the river bed, and behind the screen thus constructed cement concrete was deposited and

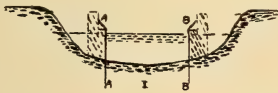


FIG. 5.—SECTION OF LOCK

allowed to become hard in the water. As there was water on each side of the screen, there was no pressure inwards from the canal, and a few guide piles of timber and some iron ties to the shore sufficed to keep the iron piling in position. When the concrete foundation had been formed up to the water surface a masonry wall was built upon it to the shore level.

The piling was made of cast-iron plates, 12 feet long, 2 feet wide and $1\frac{1}{8}$ inches thick, sharpened at the lower edge to $\frac{1}{2}$ inch thick, the plates fitting over each other. The lock, therefore, has its sides permanently lined up to the water level with iron, which conceals the concrete behind. One side of the lock was finished before the other was commenced, as the guide plates men-

tioned above occupied 10 inches of the 12 inches (the difference between 17 feet and 18 feet) to spare in the width of the lock. When both sides were completed, each end of the lock was temporarily shut in by a wall of timber and clay, and all the water was pumped out while the bottom was lined with concrete.

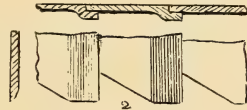


FIG. 6.—PILING AT OXFORD LOCK

The ravages of the teredo worm render the subject of metallic construction particularly interesting in the lower reaches of the Thames near London. After the fresh water becomes brackish about Erith by the sea-water of each advancing tide and in the estuary still lower at Sheerness, Southend, Herne Bay and Margate, the ravages of this marine pest reduce the durability of timber structures in the sea, where alternately they are dry and wet between tides, whose range in the Thames river and estuary is from 17 feet to 25 feet. By coincidence, in the same August number of *CASSIER'S MAGAZINE* that describes the sheet piling there appears on pages 296-297 illustrations of the teredo operations in New Zealand which resemble exactly what has taken place at Southend and elsewhere near London. The eucalyptus wood from Western Australia seems to endure longer than the ordinary pitch pine, even when the latter is creosoted; but, according to the New Zealand experience, even the eucalyptus is vulnerable. The timber which, in the experience of the present writer, will endure longest is that which is known as "greenheart," from the tropical forests of Brazil. This wood has a yellow appearance, something like lancewood, and the unpleasant results from splinters entering the hand may prove equally unpleasant to the teredo.

THE RAILWAYS OF BRAZIL

By Lionel Wiener

IX.—THE PAULISTA COMPANY FOR RAILWAYS AND NAVIGATION

THE "Paulista Company for Railways and Navigation" is the oldest of the three important companies that were floated in the State of Sao Paulo for continuing the Santos & Jundiahy line (now the "Sao Paulo Railway Company"), which the owners had no wish of extending. Their own lease covered a line to Campinas, 28 miles in length, and in 1869 another provincial bill decided its extension to Rio Claro. At this time the Province, or the State, used to pass bills in the abstract, authorizing "a company" to build the line and granting it a number of privileges. Later on only, a company was floated for building that particular line, and a further bill was needed for legalizing the "contract" then entered into between the government and the company.

After the English Sao Paulo Company had given up its right to the Campinas line the Paulista Company thought it safer to ask the leave of the Imperial Government as well, and the Provincial law was sanctioned by an Imperial one in 1869.

The contract was similar to that of the Santos road; the line was granted the 7 per cent. guarantee of interest during thirty years on a £496,031 original capital expenditure and the 19 miles protected zone on either side, but permission to increase the rates should gross earnings oblige the company to curtail the dividends was not granted. The lease was to run for 90 years, but the government reserved the privilege of buying back the line after the first 30 years.

All these bills had taken time to pass; provincial and governmental legislation were still somewhat mixed

up, and it was thought better to keep on the safe side, applying, perhaps, for over-many authorizations. Work was, therefore, not started until March 15, 1870, and August 11 saw the opening of the line to Campinas—the embryo and most important section of the future system.

While the work was in progress both the Ytuana and Mogyana Companies had been floated, forming the source of much competition to come. But the object of the Paulista line was not Campinas, but Rio Claro, beyond; and as it had been allowed to double its capital without forfeiting any of the advantages or privileges attached to the original one, work was proceeded with immediately.

The line started on January 19, 1874, and was opened to Rio Claro, a distance of 56 miles, on August 11, 1876. The company had reached a mileage of 84 miles and an unbroken run of 171 miles, all over broad gauge track, down to Santos. A far more important result had also been achieved: confidence had been fostered by the new lines, splendid returns effected. Once started on so good a footing, the rest was easy of accomplishment.

In the meantime, the Mogyana Railway, having continued its lines, the Paulista Company was in danger of seeing its privilege zone become the boundary of its territory. In 1875 it, therefore, signed an agreement for building a new line, also broad gauge, from Cordeiro, near Rio Claro, to the Mogy Guassu river, as close to its natural frontier as possible.

A loan was subscribed in London



MAP OF THE CENTRAL GROUP OF RAILWAYS—WESTERN PORTION

and the line was opened to traffic in 1880. This added another 56 miles to the system.

But there was no rest in the building at this period. Porto Ferreira, on the river, had been reached in February, 1880, and in October of the very same year the extension to Descalvado (10 miles) was decided, and opened to traffic in November, 1881. In 1882 a northerly branch across the river, called the "Santa Veridiana branch," was run to Pirassunga, 24 miles away—an extension

which created endless trouble with the Mogiana Railway, which contended that its privilege zone had been violated.

But shortly afterwards, and still with the idea of extending its own frontiers and of defending them from possible incursions by the Mogiana line, a steamer service down the Mogy Guassu was started in 1886, operating about 125 miles downstream.

There were, in addition, some 150 miles of railway, which have not

been extended; other companies have been bought up, but, owing mostly to the difference of gauge, they have been kept separate from the original lines.

At the very outset these had been successful, and have kept so; the traffic from 33,515 passengers in 1872 was multiplied five times in 1880, and thirty-five times in 1908.

The maximum declivity was 1 in 50, and the radius of curves never fell below 993 feet. The lines had been easy to build, with little earth-work and not much bridge construction. But, unluckily, in spite of all its efforts, the zone of the Paulista line was circumscribed.

The lines of the Mogyana Railway served as an eastern and northern boundary, the Ytuana formed a southern one, while another English company, the Rio Claro Railway, had actually been granted a line beyond the town of Rio Claro, extending between the Tieté and Mogy Guassu rivers to Bebedouro, with a number of branches, one of which ran due west to Jahu, near the Tieté river.

The Paulista Railway had under consideration an amalgamation with the Rio Claro Railway, then with the Mogyana, and finally with the Sorocabana. But nothing came of it except a working agreement with the Rio Claro Railway and bad blood with the others. The Rio Claro and Paulista agreed not to build new lines without each other's leave, nor to come to agreements with other roads without mutual consent. The Paulista Railway granted the Rio Claro a 20 per cent. rebate on all goods that came from the Jahu branch beyond Brotas.

Everything had been going swimmingly, with dividends never below 9 per cent. and often up to 20 per cent., and yet the company was literally penned in and prevented from any further extension. The situation had thus become intolerable. This was just about the time, too, towards 1890 that the railway craze raged fiercest, and the Paulista Rail-

way caught it and was carried away with it. The Paulista began by purchasing two small companies—the Porto Ferreira Railway, 17 miles long, and the Descalvadense, from Descalvado to Aurora, 9 miles, both 23½-inch gauge. Then suddenly, on March 26, 1892, the Paulista Railway purchased the Rio Claro Railway in a lump for the sum of £2,312,400. That is how the Paulista Railway came to own roads laid to three different gauges—the 5-foot 3-inch, which was its own; the meter gauge, which was that of the Rio Claro system, and the 23½-inch gauge of the local feeder lines.

The Rio Claro system was in splendid condition when it was purchased, with the same gradients as the Paulista's (1 in 50) and curves above 400 feet radius. The light railways had gradients limited to 1 in 33, and the curves of not less than 132 feet radius.

In 1888 the cost of the lines stood at: £6,567 for the broad gauge; £1,786 for the metre gauge; £1,288 for the narrow gauge.

The Rio Claro's first line had been leased in 1880. It ran from Rio Claro to Araraquara, with a branch to Jahu, and had the 19-mile privilege zone attached. The lease ran for 50 years, and had been granted, not by the State of Sao Paulo, but by the Government of the Union. But the company got into trouble at the very outset, and the English Rio Claro Railway Company came to the rescue and took its place, opening the main line in January, 1885, and the branch in September, 1886. The former was 86 miles long, the latter 80 miles.

As soon as these lines were in operation further extensions were applied for. All these early lines were profitable, as was bound to be the case in so rich a country.

An extension beyond Araraquara was obtained, running towards the Rio Pardo and the town of Rinção and then along its left bank to Jaticabal, besides two branches con-

ceded at the same time—the Agua Vermelha branch (from Sao Carlos to Sao Eudoxia) and the Ribeirao Bonito branch, also from Sao Carlos, but westward. It is unfortunate that the company did not immediately apply for further extensions, the Ribeirao Bonito branch having been considerably extended by another company, while the Dourado Railway and the main line had been continued northwestward both at Araraquara and Bebedouro by foreign companies.

Work had been started on all three of the Rio Claro lines when it was bought up by the Paulista Railway Company; but its system has been kept separate as the "Rio Claro Section," with which all subsequent metre gauge lines have been incorporated.

The Sao Eudoxia branch was opened in 1893 and the Ribeirao Bonito in the following year. As for the northern extension, it reached Jaboticabal in 1893, and has been extended to Bebedouro and on to Barretos in 1908. Work has been started on the last section, from Barretos to Porto Prado, on the Rio Pardo river, which is navigable for a considerable distance. The distance from Araraquara to Barretos is 121 miles.

The company has further increased its system by the purchase of the Pirapitinga line, 75 miles long, from the neighbourhood of Jahu, due west to the Tieté river, which it crosses at Pederneiras into the Sorocabana's preserves and on through Agudos to Piratininga. No further extension of this line is now intended, the recent agreement with the Sorocabana Railway prohibiting it.

Agudos and Bauru had been the goal of the Sorocabana for years, and their value increased since the North Western Railway's line was built beyond Bauru. Passing in Agudos, just short of Bauru junction, the Paulista could not compete for that extra traffic, and hence, in the middle of 1909, it decided not

only to build a short line from Pederneiras to Bauru, but further to reduce the mileage to Sao Paulo by cutting off the Annapolis loop and building a short connection from Rio Claro to Morro Pellado. Both of these have been built, and were opened to traffic in the beginning of 1910. The total distance to Saó Paulo will be 3 miles shorter by the Paulista's road than by the Sorocabana's—271 as against 274, with easier gradients. The Paulista is already applying the reduced rates as if both cut-offs were already in operation, and the two companies have come to a working agreement, probably the first agreement of any kind they have ever come to. The Sorocabana has undertaken to apply to its river routes (Tieté and Piraciba rivers) the same fares as to its railway lines. As these are higher than those of the Paulista, this company will pay the former 15 per cent. of the gross earnings in the competitive zone. Each company also undertakes to pay the other 15 per cent. of the gross earnings accruing from coffee sent from the Agudos district.

The latest increase of mileage of the Paulista system is due to the opening of a northern extension destined to tap the rich coffee plantations served only by the Mogyana Railway. This line crosses the Rio Pardo beyond Rinção and follows the right bank of the river down to Pontal. This renewed hostilities with the Mogyana Railway, and also allowed the Paulista Railway to do away with its steamers on the Rio Pardo.

Now, the Paulista's northern and western lines leave an angle in between them. The main line passes through three important towns—Ribeirao Bonito, Araraquara and Bebedouro—turning off at an angle at each of them. In each case another company has built a line into the angle above alluded to, stretching radially further and further inland and opening up new districts, whose products are bound to travel over the

Paulista system. That company has, therefore, helped these "filials," which it practically controls. The advantage of this combination is that, though the Paulista reaps the same advantages as if the lines formed part of its own system, these retain the elasticity and independence which are necessary to "penetration" railways.

The Dourado Railway starts from Ribeirao Bonoto and runs to Boa Esperança, 27 miles away. It was built from 1898 to 1902, and was laid to the 2-foot gauge.

The company recently decided to extend the system down the right bank of the Tieté as far as the Avandanda Falls, at which point that river becomes navigable. The extension runs through Bocaina and Bariry to Ibitinga. At the beginning of 1910 it was open as far as Sao Joao (65th mile).

A branch will run to Jahu and on to Ayrosa Galvaó, a station on the Paulista line near Pederneiras.

A loan of £50,000 has been negotiated, in London, as usual, for building these lines. The debentures are issued at 82 per cent. and bear interest at 7 per cent. The Paulista Company subscribed 600,000\$ (about £37,000), on condition the Dourado Company should lay its lines to the metre gauge and convert the older section to that gauge, which it has done.

The Araraquara Railway is built from Araraquara as far as Candido Rodriguez (145th mile), and is all but finished to Sao José de Rio Preto (169th mile).

As with the Dourado Railway, this road began on a very modest scale. It ran from Araraquara to Ribeirao-sinho, only about 51 miles away. But the State of Sao Paulo conceded its next section to Candido Rodriguez, with a 6 per cent. guarantee, and the Federal Government conceded a further section, which takes the line right on through Saó José de Rio Preto and the "triangle" of Minas to Jatahy, in the State of Goyaz. This line will be 575 miles long.

This company has also raised a loan in London recently, amounting to £900,000, in 6 per cent. debentures, issued at 98. The Paulista's interests are represented by a \$200,000 (£12,500) loan.

The line is built to the metre gauge, and has a branch building already, extending from Santa Josepha to Ibitinga.

The southernmost of the two remaining penetration lines is so important that it is necessary to describe it at length. This is the North Western Railway, from Bauru—the Paulista's terminal—to Corumba and the frontier of the Republic of Bolivia.

The northernmost one is the Sao Paulo & Goyaz Railway, and is in a less advanced condition. It starts from the Bebedouro station on the Paulista Railway, runs to Monte Azul (20th mile), and is building to Villa Olympia (31st mile).

Goyaz has been destitute of all railway service until now, and no fewer than four railway companies are racing to get there first.

Besides these penetration lines, there are a couple of small ones grafted onto the system—the Monte Alto Railway, quite a local road, joining the town of Monte Alto to the Paulista line, 6 miles away, and the Pitangueiras Railway, an extension of the Paulista-Pontal branch, in between the Paulista's and the Mogyana's northern lines. The Paulista has loaned this company 200,000\$ (£12,500), thus enabling it not only to build the bridge over the Mogy Guassu that will connect it with the Pontal branch, but also to extend the line to Viradouro, in the north.

With the exception of the North Western Railway, none of these lines is yet of much importance; but, as they are bound to grow into large systems, either separately or merged with the Paulista Railway, they are interesting to follow, besides their providing a new field for railway plant of all description.

The Paulista is directly interested in their welfare and development not only as feeder lines to its own system, but as an important shareholder as well, the Paulista wisely deeming any development of these lines will have an excellent repercussion on its own. These branches are, therefore, very similar to the "assisted sidings" of British India.

As for the Paulista Railway, its actual mileage, exclusive of some thousand miles of tributary lines, is only 698 miles, of which 174 are broad gauge, 498 metre gauge, and 26 are 23½-inch gauge.

The steamer service has been reduced and finally abandoned in 1903, the Pontal extension serving instead.

The lines making up the system are the following:

LINE—BROAD GAUGE, SECTION.

	Miles.
Jundiahy to Descalvado, main line.....	†140
Pirassunga to Sta Veridiana, branch.....	†24
Cordeiro to Rio Claro, branch.....	†10

• METRE GAUGE SECTION.

Rio Claro to Araraquara, main line.....	*80
Araraquara to Barreto, main line.....	*122
Barreto to Porto Prado, main line.....	*Building
Visconde de Rio Claro to Jahu, line.....	*89
Dois Corregos to Piratinunga, line.....	†75
Pederneiras to Bauru, cut off.....	Open 1910
Rio Claro to Morro Pellado, cut off.....	Open 1910
Sao Carlos to Ribeirao Bonito, branch.....	†25
Sao Carlos to Sao Eudoxia, branch.....	†40
Rincao to Pontal (Mogy Guassu), branch.....	†58

23½-INCH GAUGE LINES.

Porto Ferreira to Santa Rita, line.....	†17
Descalvado to Aurora, line.....	†9

* Lines conceded by the Government of the "Union" without interest guarantee.

† Lines conceded by the State of Sao Paulo.

Taken in conjunction with the Sao Paulo Railway, which it continues, the Paulista is certainly the trunk route of the whole of the State of Sao Paulo, all the other lines acting as feeders to its own system. The company has, therefore, undertaken a number of improvements, so as to turn it into a first-class one.

A point that is particularly worthy of note is the care the company is bestowing on the future provision of wood, both for fuel and for sleeper purposes.

The Santos harbour dues are exceedingly high, so much so that the cost of coal for locomotives is nearly

prohibitive. The Paulista Railway, therefore, uses wood fuel on the metre gauge section. But even the price of wood keeps on rising, the Paulista alone burning some 11,228,000 cubic feet annually. On the other hand, about one million sleepers are used annually by the several railway companies of the State of Sao Paulo.

After a careful examination of the various kinds of sleepers, whether hardwood, creosoted wood, or metallic, the company has adopted the first kind and started a forestry department as an experiment. This has been successful—so much so, in fact, that the company hopes shortly to grow enough wood for all its needs.

A piece of land was purchased near Jundiahy, about 252 acres in extent, and sleeper-growing—I mean experiments in arboriculture—undertaken. Some 40,000 saplings were planted, 30,000 of which were eucalypti of various species, and similar experiments have been undertaken in Boa Vista (64 acres) and Sao Bento (86 acres), where another 20,000 eucalypti have been grown, trained and studied. The choice rested on this particular species, because its wood is good and its growth particularly rapid. Thus in five years' time, the trees having grown to a height of 40 feet and a girth of 50 inches 3 feet above the ground, every other tree is cut down for firewood, which leaves more space for the others to develop. A couple of years later a further lot is cut down, and the remainder are cut when aged 12 to 15 for one batch and 18 to 20 for the last. These latter trees are then some 80 feet high and 30 inches diameter 3 feet above the ground. Each of these supplies four broad-gauge sleepers.

The cost of the trees, initial outlay and general charges of the nurseries up to the time they are cut down is about one-fifteenth part of the value of the timber—fuel wood and sleepers—which they produce.

These experiments having been so successful, the company has decided to plant a sufficient number of trees

for reaping its necessary yearly crop. These nurseries, 3,700 acres in extent, are situated in Rio Claro, between the broad and the metre gauge systems, whose main lines skirt them. The land, including some 72,000 coffee plants, was purchased at a cost of £6,631, about 36 shillings an acre.

This forestry department is not an invention of the Paulista Railway, but it is an innovation in Brazil. The cost of sleepers keeps on increasing all over the country; it would certainly be a wise policy were several companies to start similar preserves.

The steel sleepers with which the lines were originally laid were not found satisfactory, besides being too expensive, and have been abandoned, some 40,000 being withdrawn annually.

The company has been laying heavier rails on both sections, so that three types of rails are standard now: 90-pound on the broad gauge, 66-pound on the older portions of the broad gauge and on the metre gauge main lines, and 36-pound on the other metre gauge lines and on the 2-foot gauge lines.

Another creditable point is the stone ballast, this being an exceptional practice in Brazil, where stone ballasting is looked upon as a kind of luxury to be indulged in when the company's earnings are too high and it becomes necessary to increase expenditure for fear of reaching the limit above which reimbursement to the government must begin. The Paulista Railway has looked at the matter differently, and found, correctly, that money expended in stone ballasting is quickly returned in lower cost of repairs to rolling stock and in economy of maintenance.

All the broad gauge and 143 miles of narrow gauge have been stone-ballasted at a cost varying from 4s. 3d. to 7s. 1d. per running yard.

As with all the Sao Paulo railways, coffee is the most important cargo carried; indeed, "coffee" would be found to be the guiding factor in most of these railway policies. There

is little doubt that the 30,000 tons of coffee shipped in 1908 in the town of Jahu justify sufficiently the Rio Claro Railway having been incorporated for building a branch to that place.

The way all this coffee is packed into the large wagons is an art in itself. It pays high freight, and over half of the goods returns accrue from carrying this single article of consumption.

In 1908 467,000 tons of coffee were carried on the broad gauge lines and 179,500 on the metre gauge lines, while all other goods together aggregated 427,521 tons on the broad gauge section and 182,147 tons on the metre or Rio Claro.

The much larger tonnage carried on the broad gauge section is mainly due to all the Mogyana tariff being handed over in Campinas to the Paulista Railway, which doubles its tonnage. Thus, some 80 per cent. of the coffee handled by the Sao Paulo Railway in Santos has been handed over to it by the Paulista Railway in Jundiahy.

All this coffee is not carried throughout the year, but is rushed out in a few months. The total tonnage of coffee and other goods is about the same; but coffee brought in about 68 per cent. of the earnings, in spite of reduced rates, due to the fall in the coffee market, about half what they were ten years ago. The following table shows strikingly the influence the state of the coffee market has had upon the Paulista Railway. It is the average price paid by coffee per ton-mile during the last decade:

Year.	Pence.
1898.....	6.68
1899.....	6.55
1900.....	6.44
1901.....	5.58
1902.....	5.44
1903.....	5.15
1904.....	5.02
1905.....	4.99
1906.....	4.97
1907.....	4.59
1908.....	4.18

The present rates are on a descending scale per 15-mile zone. Thus, a ton-mile of coffee pays 4.67d from 0 to 15 miles, 4.34d per ton-mile from 15 to 30 miles, and so on, with a

0.24*d* reduction in each zone until 4.10*d* per ton-mile, from 48 to 63 miles. Beyond this the reduction is greater:

	Pence.
62 to 77 miles.....	3.62
77 to 92 miles.....	3.14
92 to 107 miles.....	2.66
107 to 124 miles.....	2.18
124 to 187 miles.....	1.82
187 to 243 miles.....	1.44
Above 243 miles.....	0.96

Now this table calls for three remarks:

(a) It encourages long-distance carriage;

(b) The average distance traveled by a ton of coffee in 1908 was 98 miles, thus paying 2.66*d* per mile.

(c) All the coffee handed over by the Mogyana Railway system travels from Campinas to Jundiahy only, a distance of 28 miles, paying 4.32*d* per ton-mile. Thus the average price paid per ton of coffee, excluding the Mogyana's share, is, roughly, one-third lower than appears from the averages.

There is a further reduction of 10 to 15 per cent. when the coffee is packed in casks.

The following are the percentages of the returns contributed by passengers and the principal classes of goods. They show strikingly the prominent place held by coffee traffic:

	Broad Gauge, Per Cent.	Metre Gauge, Per Cent.	Both Gauges, Per Cent.
Passengers.....	9.1	13.9	10.9
Luggage and parcels....	2.3	2.8	2.5
Animals.....	0.3	0.7	0.4
Coffee.....	59.4	59.	57.4
Other cargo.....	27.	27.	27.
Various.....	1.9	1.6	1.8

On an average,

	Brings in	And per Mile. Pence.
A ton of coffee.....	33 <i>s</i> 10 <i>d</i>	4.18
A ton of other cargo.....	15 <i>s</i> 6 <i>d</i>	2.33
A passenger.....	2 <i>s</i> 9 <i>d</i>	0.98
A ton of luggage.....	55 <i>s</i> 6 <i>d</i>	13.435
Animals, per head.....	3 <i>s</i> 4 <i>d</i>	0.50

The above statement shows that passenger traffic is important. It has always included a considerable number of immigrants. From 2,836 carried in 1883, their number rose to 71,093 in 1895, and has always kept over 1,000 a month, with two exceptions—in 1900 and in 1903—when, owing to the general state of finance the

world over, it fell to little over 4,000 only for the entire year. Between 1883 and 1908 the company carried 570,024 immigrants at about 5*s* 7*d* each.

Another item worthy of note is the falling off of first class traveling. There were 277,000 first class passengers in 1899 and but 243,000 in 1908, though the total number of passengers has increased. But this increase has been by no means a steady progression; all traffic has been severely hit during the years 1902 to 1905.

The company's property has increased in value pretty steadily, on the whole, as is clearly shown in the yearly returns per mile applying to the broad gauge section. These have followed the growth of the system from a return of £820 in 1872, when the company worked but 24 miles, growing steadily to £1,171 in 1887, when the system reached 156 miles. The present mileage was reached in 1894 and the present returns (£4,545) in 1896. Now this calls for comment, as a railway system should improve and not remain stationary, and the explanation is, as usual—coffee.

The price of coffee has been falling steadily, and every few years the railway has been obliged to cut down the rates. This has always been followed by an increase in the tonnage that has brought the returns back to their former value. The returns per mile, therefore, show the curious phenomenon of a steady fluctuation, the usual cycle extending over some eight years.

The metre gauge section, of course, shows a gradual decrease in the yearly returns per mile. "Of course" because the new lines are feeder and penetration lines, each new portion extending further into the wilds, in a steady endeavour to induce immigration to settle there and open up the land.

The working percentage is shown in the appended table from the railway's inception. It is, on the whole, a

remarkably good one, keeping under 40 per cent. on the broad gauge and frequently under 50 per cent on the metre gauge section.

The following table shows the several items of receipts and of expenditure for the year 1908:

RECEIPTS.	
Passenger traffic.....	£151,708
Luggage and parcels.....	34,866
Special trains.....	251
Animal traffic.....	6,058
Telegrams.....	13,531
Goods traffic.....	1,179,945
Miscellaneous.....	30,161
Total.....	£1,416,526
EXPENDITURE.	
Management and accounts.....	£19,457
Permanent way and works.....	155,352
Traction department.....	274,234
Traffic department.....	137,074
Telegraph and electrical departments.....	20,781
Miscellaneous.....	44,167
Total expenditure.....	£651,061

The rolling stock comprises 68 broad gauge locomotives, 59 metre gauge and 7 narrow gauge ones; 92, 84 and 9 carriages, and 1,485, 983 and 36 wagons.

The heaviest broad gauge locomotives weigh 63 tons, 47 of which are available for adhesion. They have 67.7-inch drivers, cylinders 26 by 19, and carry 200 pounds boiler pressure.

Two of the broad gauge and 44 of the 59 metre gauge locomotives are compound. The goods engines of the 42 to 47 and of the 54 to 57 class on the metre section weigh 74,779 tons, 65,900 of which are on the four pairs of drivers whose diameter is 4 feet 1 inch. The high-pressure cylinders are 13 13/16 inches and the low-pressure 22 7/8 inches diameter; the stroke of both is 27 9/16 inches. The boiler pressure is 185 pounds.

A portion of the coaching stock is of British manufacture, either of the usual compartment type or to the American pattern.

There are three dining saloons on the broad gauge, seating 24 passengers each, and sleeping cars on the Rio Claro section (Pullmans). The company is about to start running "trains de luxe," with 25 per cent. supplement on first class fares.

Of the wagons, no fewer than 953 have been built in England; 490 of

the remainder are American, 626 Brazilian, most of them from the company's own workshops, and 401 Belgian. These are pressed steel and steel tubular wagons, running on bogies and carrying 20 tons. They are all covered wagons, weighing only 7 or 8 tons, and having a remarkably low ratio of dead-to-useful weight.

Continuous brakes, on the Westinghouse system, have been attached to most of the rolling stock.

The company owns large workshops in Rio Claro for the metre gauge section and in Jundiahy for the broad gauge portion of the system. These, erected at a cost of £187,500, are probably unsurpassed anywhere, and certainly rank among the very best of electrically equipped railway shops.

The statistics relating to the locomotive and traction department are particularly interesting, because they show strikingly the effect of the metre and of the broad gauge on the railway's working and expenses.

It is always possible to compare the working of a metre gauge system with that of a broad gauge railway. But two separate companies work their lines differently, owing partly to local circumstances and partly to a difference in the methods. On the Paulista Railway, on the other hand, these differences do not exist, and any variation in the results is due to the difference in the gauge and not in the working. Whether the company did right in making use of two separate gauges is another question; and it should be taken into account that in such a country as Brazil a break of gauge is hardly a hindrance.

The price paid for coal is high, and is responsible for the determination come to by the company to use wood fuel on the metre gauge section. A ton of coal cost £4 18s 8d in 1892. Its cost in 1898 was nearly as high, and in 1908 £2 15s. But the price is unsteady and keeps high, owing mainly to the enormous dock dues at Santos.

The cost of lubricants, on the other

hand, has come down steadily from 72.945*d* in 1892 to 32.85*d* in 1908.

The number of miles run on both gauges were as follows:

Locomotive miles.....	3,904,880	3,550,495
Carriage miles.....	11,050,591	17,286,364
Wagon miles.....	738,148	1,079,557

The difference is due to the larger number of goods trains run on the metre section.

Running expenses imputable to the locomotive department are 15 pence per locomotive mile on the broad gauge and 8.52*d* on the metre gauge.

Per train mile the expenses are 23.125*d* and 10.16*d*, respectively.

Per vehicle mile, 1.11*d* and 0.06*d*, respectively.

The cost of repairs on both gauges shows a similar difference:

Per train mile.....	5.696 <i>d</i>	and 3.57 <i>d</i>
Per locomotive mile.....	3.68 <i>d</i>	and 2.94 <i>d</i>
Per carriage mile.....	0.72 <i>d</i>	and 0.34 <i>d</i>
Per wagon mile.....	0.32 <i>d</i>	and 0.14 <i>d</i>

Now the ratio of the cost of repairs per train mile on the broad and metre gauge sections is 1:1.60,

which is exactly the ratio of the gauges. These quantities on the Paulista Railway vary but little, and are, therefore, exactly proportionate.

Such is the Paulista Railway after thirty-eight years' existence. As the foregoing shows, though the Paulista is wedged in between the Mogyana on the east and the Sorocabana on the west, it has found room to expand, owing to its policy of throwing out ever-growing penetration lines in the space these two companies leave in between them. Its fate is intimately connected with that of the coffee market. But it should be borne in mind that such is the case because the coffee market is a good one and coffee traffic remunerative. Should the coffee crop give out (as happened in Ceylon), there is every reason to suppose the large landowners would turn their energy elsewhere, because the soil is rich and the climate good, and their efforts are certain to meet with success.

WEAK LINKS IN THE CHAIN

By Henry Harrison Suplee

IT is a trite saying that a chain is no stronger than its weakest link, but it is also an indication of the fact that the way to improve the chain is to cut out the weak link, or to replace it with a better one. Nearly every industrial and commercial question may be considered as a chain, formed of a sequence of events or operations, and the effectiveness of the whole undertaking is limited exactly as in the case of the chain by the defects in its least efficient element, by the unworthiness of the weakest link.

While this all seems very evident and elementary, it is surprising to perceive how continually it is ignored by men who have in hand the design of important appliances, or the conduct of great enterprises, even though these very individuals find themselves frequently hampered by the very defects which are so apparent to others. Instead of replacing the weak links, of cutting them out of the places where they are doing so much harm and of thus increasing the efficiency of the whole, they often expend great efforts in strengthening the links which are already amply strong and of improving those features which are so far ahead of the defective ones as to be already incapable of being utilized to their highest advantage.

There is probably no department of industrial service in which this lack of co-ordination is more strikingly apparent than in the all-important work of transportation, both of merchandise and of individuals. In some departments of the work the highest efficiency prevails, while in others, whose efforts

are directly connected with the completed service, the most primitive methods obtain, thus acting as a drag and burden upon the entire operation. In the face of these facts, facts which stare every one in the face and against which all active business men and many engineers have to contend, there is a continual expenditure of time, money and thought directed to improve and perfect the departments which are already far above the average, while the ones which are so sorely in need of improvement are neglected.

In nearly every great city, for example, the vicinity of the railroad terminals, as well as of the manufacturing and warehousing districts, is congested by an interminable mass of trucks, wagons and other vehicles, engaged either in bringing or removing the material and merchandise handled by the railway. This congestion is an open thing before the eyes of everyone, inconveniencing many and obstructing not only the local traffic, but also delaying and impeding the very business to which it belongs. Here is a weak link in the chain of transport between shipper and customer which limits positively and in a most aggravating manner the whole effort, an obvious and insistent defect.

So long as this weak link exists it is useless to endeavour to strengthen the other elements in the chain of events which form the journey of the merchandise. Swifter trains, greater capacity, better service on the railroad strengthening the other links in the chain act only to increase the disproportion between the efficient and defective elements.

Until the distributing apparatus at the terminal is made fully equal in capacity and efficiency to the railway service, until the weak link is made as strong as the rest of the chain, no development of the railroad operation is sensible or even intelligent.

The same is true of the transport of passengers. The true function of the railroad terminal, so far as it has any reason at all for its existence, is to aid in the effective distribution of passengers, both from the city to the various trains and from the trains to their ultimate destinations, and it is folly to shorten the train journey by five minutes and at the same time add ten minutes to the time required to get from the train to the local transportation facilities.

It is this last fact which has had much to do with the development of the automobile for general transportation.

In some instances the motor car may not be as speedy on the road as the train, although such lack is often due to speed regulations rather than to mechanical limitations. But—and here is the crucial point—the motor car starts from the passenger's door and takes him directly to the destination, to the waiting patient, to the dying wife, to the urgent meeting. It does not compel him to walk through hundreds of feet of lordly halls, to wait in a queue at a ticket window, to loiter in a waiting room until an irritating attendant sees fit to open a door and permit him to be filtered through a gate. It is distinctly "on the job," it takes him up promptly and—thanks to the engineer, the metallurgist, the mechanic—it carries him safely, comfortably and speedily all the way, it attends to the chain of events involved in transportation and *nothing else*, and the chain has no weak links. But every one cannot have his motor car and thousands must use the railroad, but the railroad is busy improving and strengthening the links in the chain which are already most

efficient and satisfactory and persistently ignores the weak ones, even disclaiming that they belong to its chain at all.

Another department in the great subject of transportation appears in the conduct of trans-Atlantic navigation. The great liner is to-day one of the triumphs of the skill of the engineer, and its conduct represents the most efficient administrative work which can be found anywhere; it is a very strong and efficient link in the chain of which it forms such an important part. Both at its departure from port and with its arrival, however, the weak links in the chain appear, and if the vessel, as is so frequently the case, has one or more ports of call, further defects are painfully evident. Apart from the sailors' hoisting tackle there is little or no effort made to use mechanical handling appliances to save time or aid the convenience of passengers in boarding or landing. Heavy trunks and boxes are carried on or off by hand, slowly, painfully and in more or less confusion. Especially in landing is there much delay caused to passengers by the continuance of this primitive method, a method which would not be tolerated in such operations as coaling, in the removal of ashes or in the handling of cargo. But, as in the case of the railroad, these weak links are ignored or disclaimed, while, at the same time, large sums are expended in endeavouring to perfect links already amply strong and efficient. The marine constructor studies every element in the design of hull and in the relation of dimensions to powering, while the engineer is perfecting engines and machinery, all with the intention of reducing the time of the ocean crossing by a few hours. The expenditure of a fraction of the cost thus involved in the first place, and the use of a trifle of the operating expense thereafter, would save (to the passenger) a greater amount of time; this being done by strengthening the weak links of terminal luggage han-

dling and leaving the ocean speed to be performed at the more economical rate with the existing appliances; using the already strong link as it is. In a recent case a trans-Atlantic liner spent between seven and eight hours at a port of call simply because the limitations of the tender service, together with the time required for the transfer of a few hundred passengers and the manual movement of about two thousand trunks, held it up. The same vessel required several hours at the terminal pier for the removal, by hand, of the same trunks and luggage, wholly because of the primitive methods employed. The weakness of these links in the chain was apparent to all, and it would require simply the applications of mechanical appliances and methods already well developed to reduce this loss of time to an inappreciable quantity. In the city of New York there has recently been erected a series of magnificent piers for use by the great steamship lines, but these landing places for thousands of passengers with their effects are almost wholly destitute of mechanical handling appliances. The links are so weak as to be almost brittle and they are stressed nearly to the breaking point with the arrival and departure of each vessel.

These are but a few examples among numbers which are painfully apparent to those who are willing to see; they constitute a burden to the community, they have their important bearing upon the increasing cost of the conduct of business and of living. The agitation about railroad freight rates is concerned almost wholly with a strong link in the chain of merchandise transport, while wholly neglecting the proportionally far greater question of terminal handling.

Let any merchant and manufacturer compare the relation which the cost of getting the goods to and from the railroad bears to the charge for railway transport, and to the value of the merchandise itself, to

discover the situation of the weak links. Even such a feeble attempt to aid matters as appears in police traffic regulation upon the congested city streets has succeeded strengthening some of the weak links, but such efforts are mere palliatives. Compare this trifling with a great question, with the herculean efforts made to secure improved terminal facilities in great cities for the trains of railways. Carry these immense improvements to their conclusion and note how suddenly the vastly strengthened link in the chain becomes coupled with one of such conspicuous weakness as to be almost grotesque. The testing engineer knows well that any sudden variation in the dimensions of a member locates with almost unerring certainty the place where the break will occur. The transportation engineer may be guided by a similar analogy and improve his results accordingly.

The great difficulty which has thus far barred the way to improvement lies in the utter lack of co-ordination between the various elements of the problem. The railroad is satisfied with the operation between its terminals; the steamship line is concerned only with the time between lights; any attempt to connect the good links of the chain is passed on to some one else, while the customer, the passenger, the shipper, the manufacturer, the industries by which the excessive cost thus produced must ultimately be paid, are at the end of the chain of unequal links.

Great trade combinations have been made and unmade, and results have been favorably or unfavorably affected, but there can be no question that the combination of all the elements which go to make up the great chain of successful transportation, rendering all the links of equal value, strength and efficiency would make for the advantage of all, while the continual misapplication of effort, ability and money upon the best and strongest links can only add to the cost without adding to the value.

THE EVOLUTION OF OCEAN STEAMERS

By M. B. Cea

WHILE the landsman is astonished at the enormous length and bulk of the great modern liner, these skyscrapers of the high seas are even more remarkable for the ingenuity shown in the construction below decks. The average traveler, carried swiftly over sea amid all the luxuries of a palatial hotel, does not realize how complicated is the mighty fabric about him.

The parallel between the modern ocean liner and the skyscraper is much closer than might be imagined. Both have been made possible by the use of skeleton steel construction. The limit in the height of buildings of stone or brick was reached years ago, when it was found impossible to carry such structures higher without increasing the thickness of their walls and supports to such an extent as to make it commercially impossible. Steel construction made it possible to raise the skyscraper indefinitely without sacrificing floor space. The problem of the great ocean liner is even more complicated. It must be built larger than any skyscraper as yet constructed, and it is subjected to many violent strains. A ship built of wood like the skyscraper of solid masonry would require a hull and interior bracing of such thickness that there would be little space available for the machinery or cabin accommodation.

In the hands of a skillful marine architect much more has been accomplished with steel construction than the mere economy of space. The safety of vessels at sea has been enormously increased, until in the highest type of modern ocean liners the element of danger is virtually

eliminated. The marvelous ingenuity displayed throughout this great fabric of steel in guarding against every possible contingency of the sea comes to the average landsman as a surprise. A great liner of 50,000 tons, such as the *Europa*, of the Hamburg-American Line, now under construction, may be controlled by a single hand. The complicated machinery for safeguarding the ship is practically automatic.

The bottom of the great hull of the liner is doubled, the inner shell being strong enough to float the ship even if the outer hull be completely torn away. It is exceedingly unlikely that water would ever reach this inner shell through accident to the main hull, but the precaution is taken so that if once in a thousand trips the ship should strike a hidden object it will prove absolutely invulnerable. The shipwrecks of the past caused by running upon hidden rocks, derelicts and icebergs are thus completely eliminated.

Even more important has been the perfection of the traverse bulkhead, made possible by the modern construction. The great ships are divided up into a score or more of perfectly watertight steel compartments. To have attempted to do this in the old ships would have used up practically the last foot of available cabin space. With these steel compartments closed, the ship is virtually converted into a number of smaller ships, or at least watertight units, which would float independently of the rest of the ship. It is thus possible to cut a modern liner into several sections and have each of them remain afloat and seaworthy.



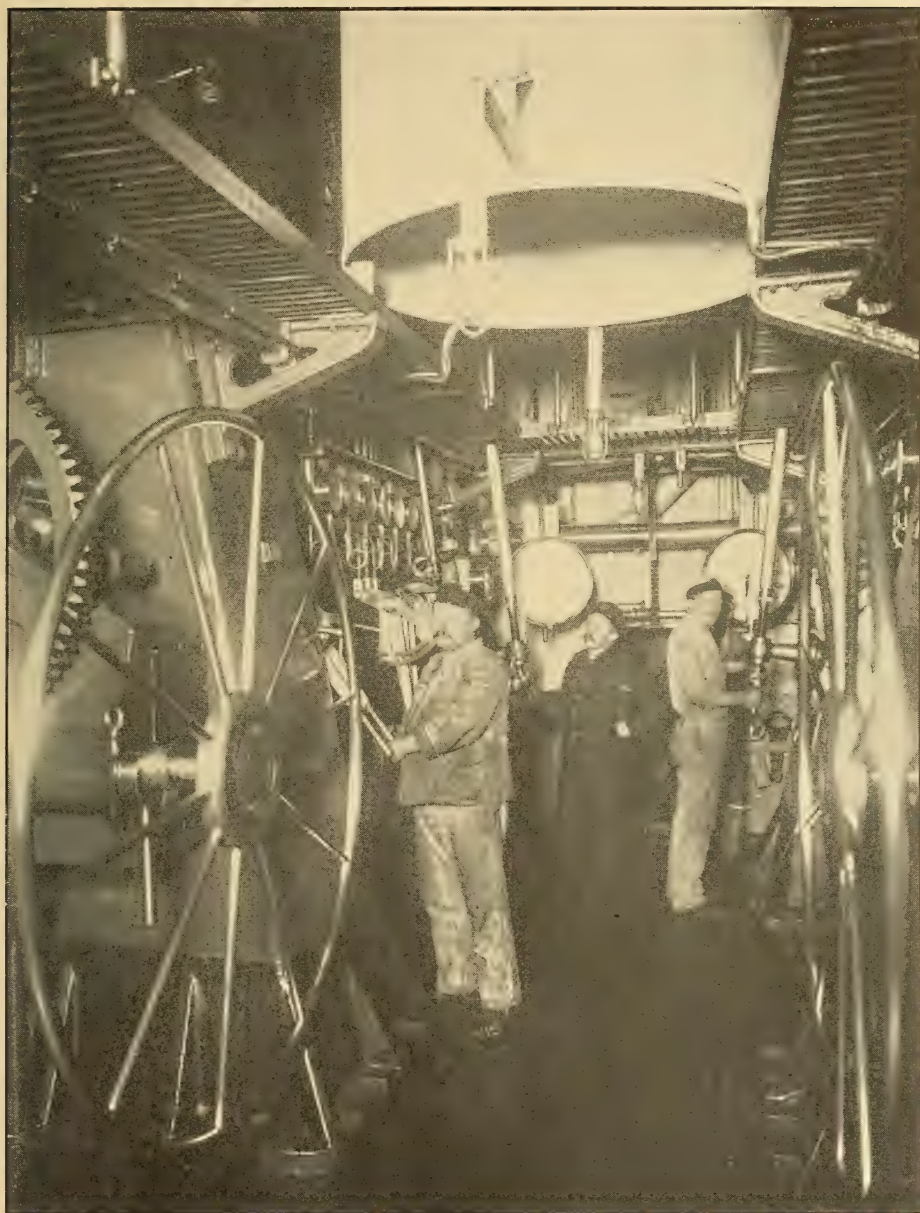
THE NERVES OF THE SHIP.

The control of these compartments from a central station on the bridge of the liner has recently been brought to absolute perfection. The steel bulkheads are pierced by doors, which may be closed at a moment's notice from the bridge. A system of electrical control which may be compared to the nerves of the human body run from the bridge to the farthest corner of the great liner. The *Europa*, the largest ship in the world under construction, is 900 feet in length, yet every part of it is practically at the finger ends of the officer on the bridge. When danger threatens, every steel compartment may be simultaneously closed by moving a single lever. To make assurance doubly sure, each doorway is connected electrically with a diagram of the ship on the bridge. If one of the doors should fail to close a small electric lamp in the diagram would instantly be turned on and would continue to burn until the door

would be closed. With this electrical diagram before him the captain is obviously master of the situation.

Aboard a modern steel ship the danger of fire is under absolute control. To guard against this ancient peril of the seas, ingenious thermostats are installed in all parts of the ship with electrical connections to the bridge. A second diagram of the ship indicates each of these stations. A rise of temperature in case of fire is announced instantly by the ringing of a bell and the burning of an electric lamp on the diagram. The officer on the bridge is certain of being informed by this sleepless electrical guard of the beginning of a fire and of its exact location. The bridge of a modern liner is the telephone central for the entire ship, and it would be but the work of a moment to telephone to the most remote part of the ship and thus bring assistance without loss of time.

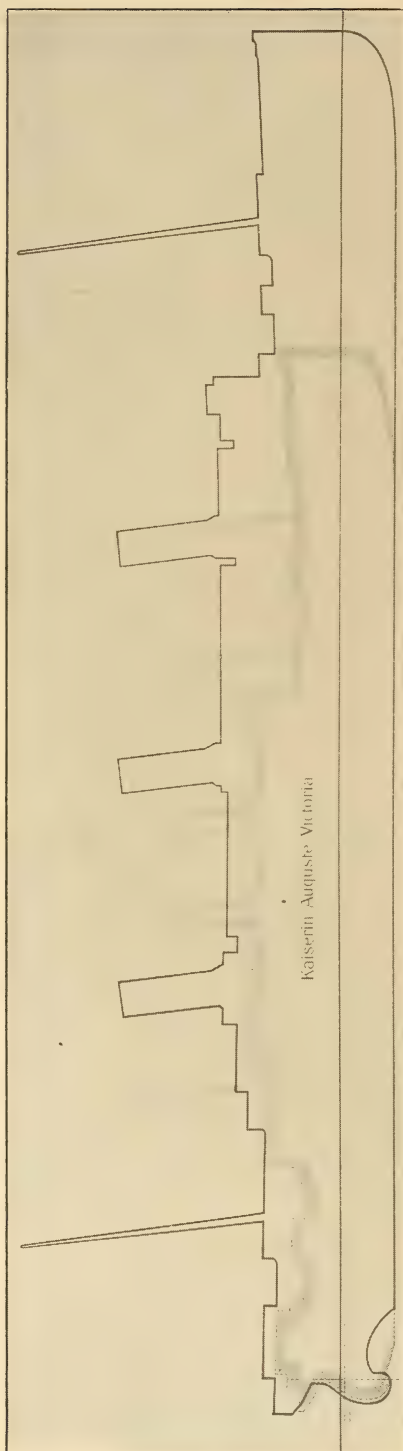
The safety devices of the modern



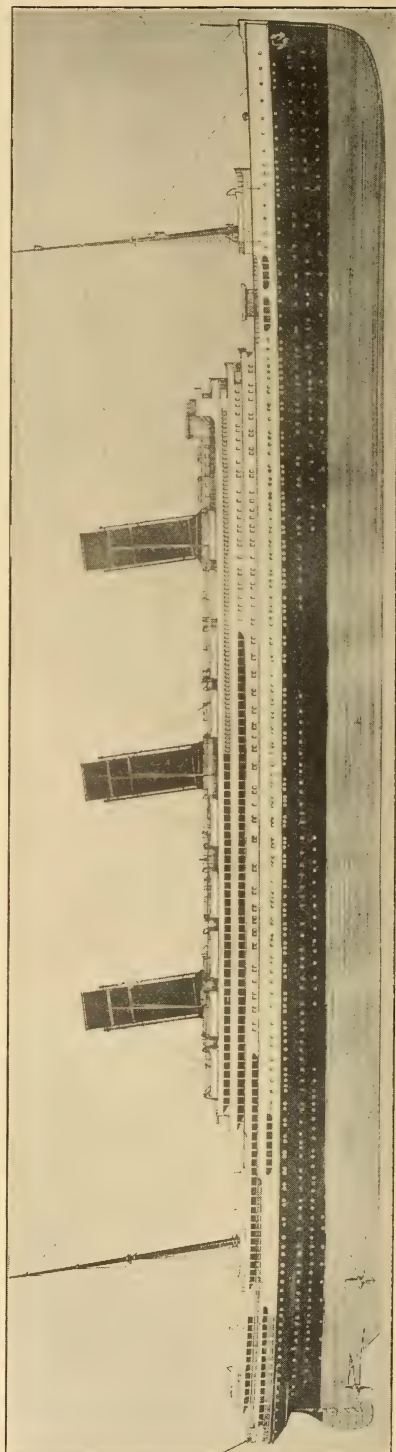
WHERE THE NERVES LEAD TO.

ships act even more quickly than the telephone. The terrifying cry at sea of "Man overboard!" also finds the captain of a modern ship prepared to render instant service. With the rigid discipline aboard ship, it would be possible to have a boat overside

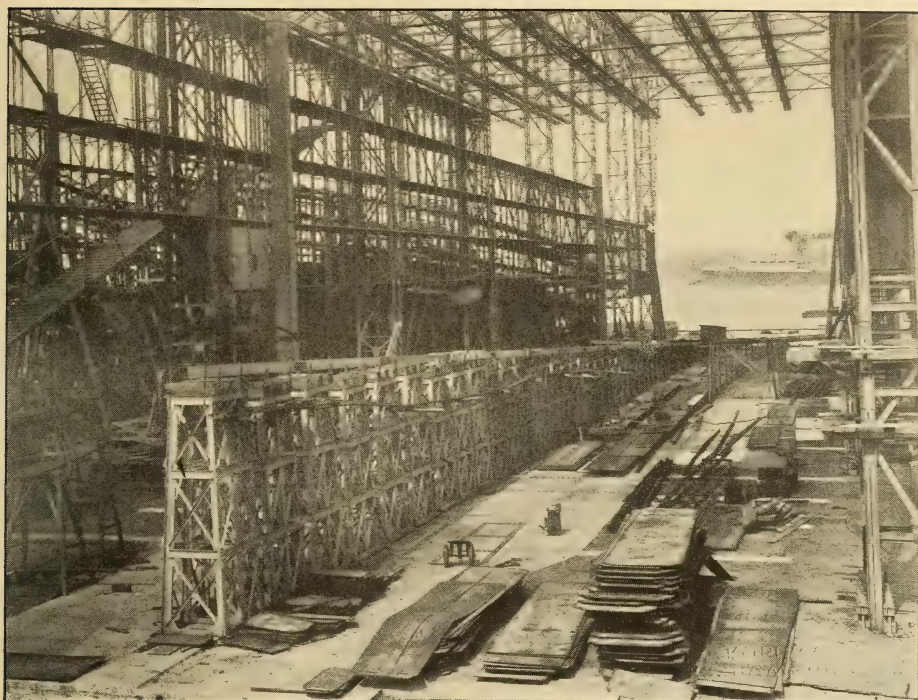
in a few minutes, but the great speed of the modern ships would carry them some distance before they could be stopped. This is anticipated by equipping a life preserver at the extreme stern of the ship, which is controlled by an electric device from the



A COMPARISON OF THE "KAISERIN AUGUSTE VICTORIA" WITH THE "EUROPA"



"EUROPA," 900 FEET LONG. HAMBURG-AMERICAN LINE



VULCAN COMPANY WORKS AT STETTIN, WHERE "EUROPA" IS UNDER CONSTRUCTION.

bridge. By touching a button the life preserver is instantly dropped overboard from the stern, while a bell on the bridge is rung to show that the life preserver has been de-

tached. The captain on the bridge of a modern ocean liner, in short, operates a great keyboard which brings the uttermost parts of the ship under instant control.



THE NEW SHIPPING CREED

By Walter M. Oestreicher

FOR the first time in many years the mercantile interests of New York City seem to have agreed on a practical working basis in their effort to solve the freight and shipping problems of the metropolis. They have, of course, known for many years that the movement of freight is more expensive there than elsewhere, but only recently have they been furnished with a sufficiently lucid diagnosis of the ailment to enable them to put their fingers on the sore spot. They now know that the separation of the factories and wholesale rooms from shipping termini by miles of congested thoroughfares, and the consequent necessity to cart every shipment through these streets, are at the bottom of the trouble. By inference, the remedy of moving the factories and wholesale rooms to points near the shipping terminals suggested itself, and thus the theory has been developed that the base of supplies must be near the centre of distribution. In other words, factories and shipping rooms belong where the warehouses, the piers and the railroads are ready to take care of their output. This means that factory structures of the future will—or ought to be—erected near the shipping terminals. The first thing to do, then, is to find the proper sites, and hence the waterfront immediately demands attention. Indispensable to extensive shipping and immovable in its nature, it is the logical soil for the growth of shipping communities. Factories and railroad tracks, on the other hand, can be transferred. Along the waterfront, therefore, must be the sites of

future manufacturing sections. As soon as this point is settled, the mind's eye immediately perceives a great transformation in the area back of the piers; it becomes veined with railroad tracks and studded with factory buildings and warehouses. Wholesale commerce, instead of rubbing elbows with retail trade, struggling for breathing space in tenement districts, and spilling its precious output into the teeming streets, thus becomes independent of the surface car, of the traffic policeman, of the pleasure vehicle and the pedestrian, and in its own territory unfolds its wealth, unhampered and undisturbed.

New York City is the first large commercial centre to have put the new shipping idea into concrete form. In South Brooklyn, Mr. Irving T. Bush, president of the Bush Terminal Company, has established such a modern shipping centre. Twenty blocks of waterfront were at his disposal when he first started to preach his gospel of scientific and systematic freight movement. The South Brooklyn beach did not prove a path of roses. First he had to build immense piers; then he added warehouses by the score, and, finally, after many struggles and disappointments, he succeeded in inducing the railroads—all ten that run into New York City—to send their trains to his Union Depot. But the hardest task was still ahead of him. The fact that every conceivable shipping agency was ready for merchants who would locate nearby did not seem sufficient to attract them to the vacant ground behind the Bush piers and adjacent to the Bush tracks. So he cut the Gordian knot by erecting



A VIEW OF THE BUSH LOFT BUILDINGS

model fireproof steel and concrete loft buildings, each five and ten times the size of the ordinary factory structure, and then he sent out word that he was ready to lease space to all responsible comers, undertaking to save them thousands of dollars annually both in insurance and by having any railroad over whose tracks they might care to ship call at their very doors and transport their goods in the original car to any part of the country. The offer amounted to the complete elimination of all trucking and reloading, with its immense costs, delays and responsibilities, and unnecessary expense.

Irving T. Bush does not claim that the great plant he has established must remain the only one of its kind. He argues that what he has done on twenty city blocks others can do on more or less, and the municipality may do likewise any time it can clear the land back of its piers sufficiently to permit of the erection of loft and factory structures. The only thing he does assert is that he is the pioneer; that, for the present, the stretch of waterfront developed by him is the only practical demonstration the country over of the new shipping creed, and that this creed is the creed of the future.

"The evil of commercial traffic congestion in New York City is a glaring one, and every thinking merchant is aware of it," said Mr. Bush, in discussing the situation. "There is hardly a large manufacturing or wholesale house in New York City that could not reduce its operating expenses by large sums if this congestion was not a fact. If it were inevitable, it would be bad enough; but there is a good deal of traffic in the streets of New York that does not belong there, and the deplorable thing is that the general public seems to make no effort to remove it. If every truck moving over the circuitous route of the streets of New York to a railroad or a steamship terminal were removed, the remaining traffic could be so easily handled that a good many of our passenger troubles would speedily adjust themselves. The trouble is that our geographical conditions are such that the railroads do not connect with the waterfront and the warehouses, as they ought to do, and as they do in some other cities. As matters stand here to-day the transfer of freight by trucks to factories and between the various transportation corporations is a necessity. It seems to me that a great deal of this freight could



A TYPICAL LOFT IN THE BUSH TERMINAL COMPANY'S BUILDINGS

be diverted. Freight in transit might very properly be sent to outlying points about New York direct from car to car or from boat to car. When we consider the great street obstructions formed by every truck, and the comparatively small amount of goods

that one truck can carry, as compared to the very much larger capacity of the steamship or railroad float, it would seem that trucking in the manner described represents a waste of effort and a neglect of opportunity."

(To be concluded.)



THE NOISELESS TYPEWRITER

The Noiseless Typewriter

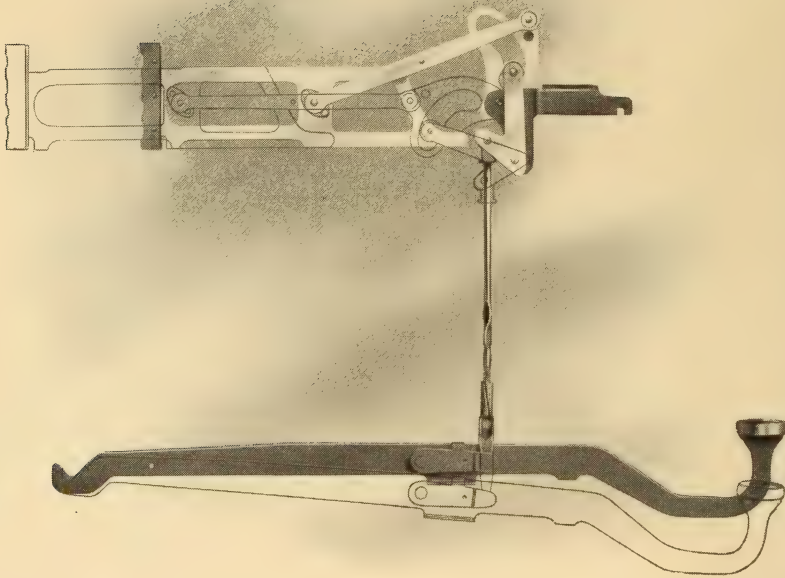
MORE than six years ago there was a brief note published in this magazine, calling attention to the desirability of producing a mechanical writing machine which should be free from the noise and clatter usually considered inherent in such machines. Speaking editorially, we said:

"A noiseless typewriter is something devoutly to be hoped for. The clatter of the average machine ought to have been a fruitful stimulus to inventors long ago, but typewriter ingenuities seem to have followed other lines than that of producing noiseless working, so that the production is still an open one. Not only is the continual din of the machine nerve-straining to others than the operator, but from an engineering standpoint it means wear and tear of mechanism and misspent energy—imperfect design and construction—which thoughtful design and construction ought to overcome to a measurable degree."

During the interval which has elapsed since this call was issued to inventors and mechanics, the seed thus sown has sprouted and attained full fruition, and to-day the noiseless typewriter is an accomplished fact.

The early attempts to reduce the noise of typewriting machines were directed principally towards the absorption of the noise after it had been produced, and such appliances as clamps, rubber feet, special pads, platens and the like, demonstrated the desire of manufacturers to meet the demand for less noise. All such remedies, however, were of little avail, since the fundamental action of the machines, consisting of a succession of sharp hammer blows upon a firm platen necessarily involved such a penetrating noise as to be incapable of concealment by any such palliatives.

The real remedy lay deeper in the construction of the machine, in the design of an action which should not produce noise at all, and it is this



NOISELESS TYPE-BAR ACTION

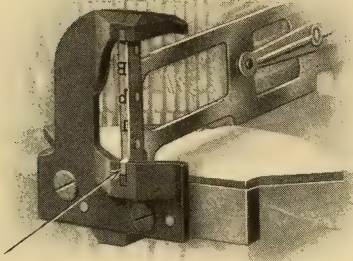
most desirable result which has been achieved by the engineers and inventors who have been working upon the problem for the past seven years.

Since the principal cause of the noise produced by the ordinary type-writing machines is produced by the pounding of the type-bars upon the platen or roller, it became evident that this method of action should be modified. The result has been the substitution, in the noiseless type-writer, of pressure instead of blows, to make the impression upon the paper. While this removed the principal source of the noise, there were other contributing elements to the general clatter of the older machines, and in the new machine these are wholly removed by the use of noiseless ratchets, in which the pawls are lifted clear of the teeth, for the earlier devices which produced the nerve-rasping sounds so familiar in the busy office.

The employment of ball bearings

in all places where their use will minimize friction and prevent wear and noise is an essential element in noiseless construction. The escapement is designed so as to obviate noise without interfering with speed and reliability and thus all disturbing sounds are prevented, obviating any useless attempts at smothering noise.

The general arrangement of the machine is clearly shown in the illustration. The type-bars are arranged in a semi-circle, radiating to the printing point, and their motion is horizontal, pushing the type against the paper and platen by a combination of toggle and cam, which gives an increasing pressure at the moment of contact, similar to that long since recognized in every printing office as the correct method of obtaining the best effect. The type-bars are of a form permitting accurate guidance and maximum stiffness, the type itself being riveted firmly to the end.



LOCKED TYPE-BAR AT PRINTING POINT

Each type-bar unit is capable of individual adjustment, so that the impression may be regulated according to the area of surface, permitting entire control of the pressure upon the small punctuation marks, as well as upon the full-faced capitals. A general adjustment of the carriage enables the whole pressure to be regulated according to the number of sheets used, as in case of manifolding. The adoption of the pressure principle enables a firm steel platen to be used behind the paper instead of requiring the rubber roller to receive the blows of the type, thus giving especially good results in manifolding and prolonging the life of the roller and ribbon.

At the moment of printing, the type-bar is locked at top, bottom and sides, as shown in the illustration, so that perfect alignment is secured and maintained at all times.

In order to obtain perfect assurance that the machine will not become noisy after continual use, the noiseless typewriter has been tested under power at a rate corresponding to seven years of constant and severe service without revealing appreciable wear or noise.

It is only after long years of experiment, test and investigation that this notable machine has been permitted to be shown and offered, but the demonstrations of its satisfactory performance and of its full right to

the claim of the title of "noiseless" have been so convincing that it is now placed upon the market.

The works of the Noiseless Typewriter Company are at Middletown, Conn., and its main offices at 320 Broadway, New York City.

Record Concrete Laying at Gatun Locks

ALL hourly records for concrete laying were broken on October 6 (1910) by the cableways used in constructing the great locks on the Panama Canal at Gatun. Two million cubic yards of concrete are to be used in building these locks. Lidgerwood cableways are used for placing the concrete. These cableways are arranged in duplex form on four pairs of towers.

The pair of cableways which broke the record are known officially as "strand A" and "strand B" of Cableway No. 1.

Strand A placed 49 cubic yards in one hour, and strand B placed 50 cubic yards during the same hour. This means that the carriage on each strand made twenty-five trips per hour. The cableways were sold under a guarantee that they would make twenty trips per hour.

These cableways are arranged to give higher carriage speed than was ever attempted before for this class of work. This speed is rendered possible by important improvements made by Mr. Spencer Miller in anticipation of just such needs. With these improvements it is possible to use carriage speeds up to 2,500 feet per minute, as against speeds of 800 or 900 feet per minute, which were as great as were before practicable. The cableways each have a span of 800 feet between towers. They are actuated by electricity, and the control is as easy and simple and of the same character as the control of an up-to-date electric train. One operator controls the entire operation on each strand.

Fire Loss in National Forests

A ROUGH estimate of the fire loss upon the National Forests in Montana and Northern Idaho, upon which the forest officers of the United States Department of Agriculture have been engaged since the fires were put out, puts the total amount of timber killed or destroyed in this one district at over six billion board feet, while the area burned over is put over one and one-quarter million acres.

The heaviest losses were in two Idaho forests, the Cœur d'Alene, where over three billion board feet of timber are reported killed or destroyed and over 450 thousand acres burned over, and the Clearwater, where one billion feet of timber were killed or destroyed and 300 thousand acres burned over. On the Helena National Forest, in Montana, the loss in timber is believed to have been 500 million feet, on the Cabinet Forest 400 million, and on the Lolo Forest 300 million.

The widest point this burn has a width of about forty miles, but its shape is very irregular, as it was really a union of a number of separate fires, driven to fury by the fierce hurricane of August 26. To the west of the Idaho-Montana boundary, in the region of this fire, lies a very inaccessible mountainous country, into which, on account of the absence of trails and of forage, it was almost impossible for forces of fire fighters to penetrate. When the hurricane arose it drove the fires upon the parties which were hewing a way towards them, forced these parties to seek refuge wherever it could be found and swept down upon the forests, where the fires were up to that time generally well in hand. The extensive losses are ascribed to the combination of hurricane and lack of means to get to the fires and put them out before the storm came. On the forests, which were best equipped for controlling fires, the results achieved are regarded as a demonstration of the efficacy of the

fire-fighting methods employed, even under highly adverse natural conditions.

It is believed that, as usually happens in the case of big fires, there will be found to be considerable areas of living timber within the regions now mapped as entirely burned over. As fast as possible, however, the forest officers are locating and estimating the bodies of timber killed but capable of being lumbered if taken in time. There will be an enormous quantity of fire-killed timber, both on the National Forests and on private lands, to be disposed of as soon as possible, since if not marketed quickly it will not be worth cutting at all.

The Department of Agriculture will push vigorously to dispose of this fire-killed timber. As with all other National Forest timber, it will be sold on the stump to millmen, who will lumber the land, paying a set price per thousand board feet for the timber, and conforming to whatever regulations are stipulated in the interest of the forest. Pending the disposal of this fire-killed timber, future sales of green timber from the National Forest, which were badly burned last summer, will probably be greatly restricted, if not entirely suspended.

Since the amount to be disposed of is doubtless greater than can be marketed in any event, and since it is better for the country that the timber should be utilized than that it should go to waste in the woods, the price at which it will be sold will be lower than would be asked for the timber under ordinary circumstances. Generally speaking, Secretary Wilson does not regard it as a wise public policy to sell off the National Forest timber, except when it is in reasonably good demand, for the country is sure to need the supply badly later on. But with the fire-killed timber it is a case of now or never. Consequently there is an unusual opening for lumbermen who are ready to purchase National

Forest stumpage at bargain prices.

How much of the six billion feet which was either killed or burned up in Montana and Northern Idaho can eventually be salvaged it is, of course, impossible to predict. If it were all a total loss, and if its stumpage value were put at the average price at which National Forest timber was sold last year, it would be the equivalent of a money loss of about fifteen million dollars.

It is believed that last summer's fires either burned up or killed between one and two per cent. of the total stand of National Forest timber. At the present rate of cutting from the National Forests, six billion feet is equal to twelve years' supply; but it is less than one-sixth of a single year's cut in the entire country, or enough to keep all our lumber mills busy for something under two months.

**The Duff Manufacturing Company of
Pittsburg, Pa., Purchases the En-
tire Forgie Plant**

THE business of William Forgie, of Washington, Pa., has passed into the hands of the Duff Manufacturing Company, of Pittsburg, Pa., which has purchased the entire plant and all rights and privileges of making the oil-well jacks, originated in the early days of the business by William Forgie.

Most of the machinery in the Washington plant has been transported to the Duff factory, where the well-known oil well jacks, formerly made by the Forgie Company, will now be built.

This jack, which is for work in the oil fields, was designed by William Forgie, a pioneer in the jack business, who was exclusively a maker of jacks for oil works operators. The business was started many years ago on a small scale, when Mr. Forgie began as something of an itinerant manufacturer. He made a number of jacks and then traveled about the oil districts of Western Pennsylvania, Southwestern New York and West Virginia selling them directly to the oil men.

The business prospered and Forgie's name, connected with oil well jacks, was known throughout the oil district. His business developed and a plant was built in Washington. Passing years saw many improvements and it was no small concern that the Duff Company acquired when it prevailed upon the veteran manufacturer to dispose of his plant.

There is something of a parallel between the beginning of the Forgie and Duff plants. While William Forgie was making jacks and traveling as his own selling agent among the oil men during the early days of the industry, the Duff Company was being established on a small scale in Pittsburg, then the city of Allegheny. This was in 1883, when the original Duff opened a small plant on the site of the present pretentious factory, where the long line of Duff and Barrett jacks are made.

While the Duff people will continue to manufacture its own highly-efficient oil well jacks they will take up all the original Forgie models and place them on the market. The Forgie jack will be added to the Duff list of products, and, while the old name will no longer be used, the Duff Company falls heir to the big Forgie business, which was built up from a small beginning during the early days by the man who started as an itinerant maker and selling agent combined and ended as a manufacturer.

The Ideal Electric & Manufacturing Company, of Mansfield, Ohio, announce that the Machinery & Supply Company, of 61 Fremont street, San Francisco, Cal., have been appointed their Western agents. The Machinery & Supply Company now carry a full line of "Ideal" apparatus, covering the principal sizes. This line includes alternating and direct-current generators, induction motors, both of the slip-ring and squirrel-cage types, special direct current and alternating current elevator motors, and also a complete line of direct current motors.

Cost of Traveling by Rail in Europe and North America

In the November number of the "Official Guide" appeared an instructive article on "The Cost of Traveling by Rail in Europe and North America." This article takes up the question as to whether traveling by railroad in Europe is or is not more expensive than in the United States, and treats the subject from all points, taking into consideration the matter of comfort, speed, etc., in order to draw a fair comparison.

The conclusion is reached that, taking everything into consideration, a first class ticket in Europe may be fairly compared, as to price and accommodations given, with a first class ticket in America plus a parlor-car seat. The following deduction is given:

"Traveling first class, 2,154 miles in Europe, at 30.4 miles per hour, with an average of 168 pounds of baggage, cost \$95.97, or 4.46 cents per mile.

"Traveling first class, 2,154 miles in North America, at 38.6 miles per hour, with an average of 168 pounds of baggage, including reserved seat in parlor car, would cost \$61.56, or about 2.86 cents per mile.

"In this last calculation the cost of extra baggage and of parlor car seats is reckoned exactly the same as for 2,211 miles—that is, respectively \$2.75 and \$9.70.

"Under the above conditions the cost of railway traveling in Europe is over 55 per cent. higher than in North America.

"To state the matter differently: A passenger with a trunk in Europe would travel first class 500 miles in 16 hours and 27 minutes at a cost of \$22.25, while a passenger in North America with the same baggage would travel in a parlor car 500 miles in 12 hours and 56 minutes at a cost of \$14.30."

Comparing second class travel in Europe with ordinary day coach travel in America, the article goes on to state:

"The price of second class tickets varies from 60 to 75 per cent. of the first class tickets. The average is about 66 $\frac{2}{3}$ per cent. The extra charge for baggage in Europe is the same for a second class passenger as for one holding a first class ticket, and a comparison may, therefore, be fairly made with the first class fare in America without a parlor car seat. This gives the following results:

"The cost of traveling 2,154 miles second class in Europe, at 30.4 miles per hour, with an average of 168 pounds of baggage, is \$69.26, or 3.21 cents per mile.

"The cost of traveling 2,154 miles first class in America, at 38.6 miles per hour, without parlor car seat, with an average of 168 pounds of baggage, is \$51.86, or 2.41 cents per mile.

"A traveler made sixteen journeys in Europe with hand baggage only, covering 1,284 miles, for which first class fare amounting to \$46.72 was paid, the average speed being a trifle over 28 miles an hour. This rate figures out a trifle over 3 $\frac{1}{2}$ cents a mile. If second class tickets had been purchased the cost at the published rates for the same routes, with hand baggage only, would have been \$30.93, or 2.41 cents per mile.

"At the rates above stated traveling first class in America for a similar distance in ordinary coaches, with hand baggage only, would cost 2.28 cents per mile, or \$29.28 for the distance of 1,284 miles. This is \$17.44 less than the first class fare in Europe for the same distance under similar conditions, and \$1.65 less than the second class fare.

"The cost of traveling second class in Europe with only hand baggage is, therefore, about the same as the cost of traveling first class in America with only hand baggage. The cost of traveling second class in Europe with baggage of the weight given above is 33 $\frac{1}{3}$ per cent. higher than the cost of traveling in America with the same baggage. This percentage will not be as large, of

course, with a smaller amount of baggage, but whatever is paid on the continent of Europe on that account in the great majority of cases will be found to be in excess of the cost here.

"Various other comparisons may be made in the figures given, but they all show that, under equal conditions, the ordinary passenger fares in North America are considerably cheaper than in Europe, notwithstanding the much greater density of population in the countries of the latter."

Five and One-Half Miles per Minute

One mile a minute is usually regarded as considerable speed for anything. Wide experience has proven the fact, as stated in all standard engineering text-books, that it is impracticable to run ordinary iron and steel pulleys for mill and factory work at a greater rim speed than this (five thousand to six thousand feet per minute).

So a pulley which will safely sustain a rim travel of five times that speed—more than five miles a minute—must possess unusual mechanical merit. A remarkable test recently conducted with a Dodge iron spider wood rim pulley, which ran safely at more than five and one-half miles per minute, is described in a little book just received from the Dodge Manufacturing Company, of Mishawaka, Ind., who will be glad to send a copy to any one interested who mentions this publication. The test is interesting and the book well worth reading.

More Work in Pennsylvania Car Shops

The Pennsylvania Railroad has issued orders for the running of its mammoth engine and car repairing and building shops here from four to five days a week. The shops have been running four days a week full handed. Now the men get one more day's work a week, and intimations are out that the additional one-half Saturday day will soon be added.

Automobile Forgings

The manufacturers of automobiles have learned through experience that too great care cannot be taken as to the material put into their cars, and to-day the purchasers of automobiles are fully as much alive to the value of quality and will not tolerate inferior goods.

A make of auto forgings, the high reputation of which has increased with the automobile industry itself, and which to-day is known pre-eminently both for its quality and design, being now recognized as a necessary requisite in the building and equipment of a good car, is that of the Billings & Spencer Company, of Hartford, Conn.

For more than forty years this well-known firm has been engaged in the manufacture of drop hammers, forgings and machine tools, and their products were considered as standard, even at the time of the birth of the automobile.

The long experience they possessed in the production of other classes of drop forgings well fitted them to take a front place in this then-new line of effort, while the well directed and careful attention they at once gave and still continue to give to the production of forged automobile parts and tools have kept them and their products well in the fore, so that the maker who installs their forgings in his cars and the purchaser who uses his cars both feel secure in their strength, durability and design, thus adding much to the reputation of the former and the safety and pleasure of the latter.

The annual meeting of the National Association of Cement Users will be held in New York during the Cement Show, December 14 to 20.

The Annual Meeting of the American Society of Mechanical Engineers will be held in New York City from Tuesday, December 6, to Friday, December 9, at the United Engineering Building, in Thirty-ninth street, near Fifth avenue.

Friction Losses—What Tests and Experience Show When Dixon's Flake Graphite is Added to the Lubricant

SCIENTIFIC tests by prominent authorities have proven conclusively that friction losses are much reduced and the carrying capacity of the bearings greatly increased when the lubricant contains the correct proportions of Dixon's pure flake lubricating graphite, and these tests are proven by actual experiences.

Sometime ago Professor W. F. M. Goss, Dean of the College of Engineering, University of Illinois, made some tests with the Dixon pure flake lubricating graphite on ball bearings. As a result of these tests, Professor Goss says, in part, that the following conclusions may be drawn:

"A combination of graphite and lard oil makes up a lubricating mixture which, when applied to ball bearings, will accomplish everything which lard oil alone will do, and which, at the same time, will give a lower frictional resistance of the bearing and permit a large increase in the load which it may be made to carry.

"An oil as light as kerosene, when intermixed with graphite, will be converted into an effective lubricant for ball bearings when operated under light or medium heavy pressure.

"Even so viscous a lubricant as vaseline will better perform a given service in the lubrication of ball bearings when supplemented by small amounts of graphite. The bearing to which the mixture is applied will work with less frictional resistance and will carry a heavier load than when vaseline alone is used.

"The admixture of graphite with either a liquid or viscous lubricant serves both to reduce the friction and to increase the possible load which a bearing thus lubricated can be made to carry."

The Joseph Dixon Crucible Company, of Jersey City, N. J., have a record of Professor Goss' extensive

tests with graphite as a lubricant published in pamphlet form under the title of "A Study in Graphite," which is sent free on request.

The Use of Perforated Metal.

The use of perforated metal in the many ways for which it is so well adapted is constantly increasing, it having proved itself superior to wire cloth for screens on account of its strength, durability, uniformity of hole or mesh, and the fact that it can be arranged with certain portions left blank, which latter is an impossibility with wire mesh.

The Hendrick Manufacturing Company, of Carbondale, Pa., have an exceedingly large and thoroughly up-to-date plant for the manufacture of perforated metal for all uses, which is equipped with the latest improved machinery.

They make a large assortment of standard patterns, including round-hole, with holes varying from 3/64-inch round and 1/16-inch between centres up, special plates for malt houses and breweries, square-hole screens of all sizes, needle slot screens, diagonal slot screens, "Hit or Miss" perforated plates, spark arrester plates, as well as revolving screens for all purposes.

A large portion of their plant is devoted to sheet iron and steel construction, with special facilities for the manufacture of elevator buckets of every description, and conveyor lining, troughs and flights.

They invite correspondence from those desiring perforated metal for any purpose, and their engineering department will be glad to send full information and give special points regarding its best uses.

Harper & Bros. have just announced the publication of two new books, "How to Know Architecture," by Frank E. Wallis, and "The Story of Great Inventions," by Elmer E. Burns.

William John Macquorn Rankine, who for so many years was the leader in the engineering profession of the English-speaking countries, was born at Edinburgh on July 5, 1820. He received his early training in mathematics, mechanics and physics from his father, David Rankine, secretary of the Caledonian Railway Company, and also at the Ayr Academy and at the Glasgow High School. He studied Newton's *Principia* at the age of 14, and acquired most of his knowledge of higher mathematics by private study.

He worked under his father on the Leith branch of the Edinburgh & Dalkeith Railway, and in 1838 became a pupil of Sir John MacNeill, being engaged on surveys and improvement works in Ireland. Afterwards he worked under Locke and Errington, and in 1848 began his researches into molecular physics, which led to the dominating part which he took in the creation of the science of thermodynamics. His paper on "The General Law of the Transformation of Energy" was presented before the Glasgow Philosophical Society in 1853, and on "The Geometrical Representation of the Expansive Action of Heat," before the Royal Society. In 1855 he became Professor of Engineering in the University of Glasgow, and for nearly twenty years he poured forth an immense amount of technical literature of the highest order in the form of communications to the engineering journals and in the series of books: Shipbuilding, Applied Mechanics, The Steam Engine, Civil Engineering, Machinery and Millwork, etc.

He died on December 24, 1872, leaving behind him an imperishable monument in the form of his writings and in the additions which he made to the sum of human knowledge concerning the forces of Nature.



WILLIAM JOHN MACQUORN RANKINE

See Reverse Side.

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CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

Vol. XXXIX

JANUARY, 1911

No. 3

THE PARIS AERONAUTICAL EXHIBITION

By W. F. Bradley

BETWEEN sixty and seventy firms exhibiting fully-equipped aeroplanes or motors specially designed for aerial work at the second annual French Aerial Exhibition, held in Paris from October 15 to November 2, 1910, are sufficient to prove that the building of flying machines has now become an established industry. The fact that the aeroplane has passed from the experimental to the practical, and even the commercial, stage, was patent to even the most casual observer. A total of 306 firms filled the largest hall available in Paris with what is undoubtedly the best collection of aeroplanes, air ships, aerial motors, accessories and fittings that the world has ever seen.

There was no room for the experimental machine, by which is meant the machine that has not gone through its preliminary tests. It is a point of considerable significance that there was hardly a complete machine or model of a flying machine that had not actually flown before being brought to the exhibition. The art of flying is advancing so rapidly that the public has not time to spare over devices existing only on paper, which are expected to be able to give good results in the air. It is true that there were some theoretical schemes, but they were lost in the

greater importance of the appliances of the firms having already won names and established big business connections.

Among the leading firms most important advances are to be found in structural details. There are not any radical changes in design, but in the matter of strength, finish and workmanship there is a world of difference between the leading makes of aeroplanes of to-day and those of a year ago. An important feature is the strong tendency shown by some of the leading makers towards the use of metal for the framework of aeroplanes. The French Wright biplane, although employing American spruce for its running gear and main transverse members, now has steel tubes for the stanchions separating the two main planes. The Voisin brothers have abolished wood entirely, with the exception of the fuselage receiving the pilot's seat, the essential framework being constructed of steel tubing. Bayard-Clément, in their little Demoiselle, confine the use of wood to a portion of the wings. Robert Esnault-Pelterie, who has now produced a most pleasing and successful monoplane, builds it entirely of steel tube, and there is not an inch of wood to be found on the Breguet biplane.



GENERAL VIEW OF THE PARIS AERO SALON

It is, perhaps, too much to say that the use of wood is limited while there are such firms as Antoinette, Blériot, the two Farman and Sommer employing it exclusively; but it is certain that metal structures will continue to find favour among manufacturers building aeroplanes in series. As improvements are made and smashes become rarer, it will doubtless be found that metal will be employed for the fuselage and landing chassis, with wooden wings, in the case of monoplanes, built in quantity and stocked ready for immediate delivery in case of breakage. Already several firms of coach builders are specializing in monoplane wings for standard machines, offering them cheaper than they can be obtained from the maker of the aeroplane.

Piano wire is quickly dropping into disfavour for wing stays, its use being confined to trussing frames and other parts subject to lesser strain. Its place is being taken by stranded wire cable, steel ribbons, or even by

steel bars and tubes. Most of the leading makers now use stout wire cables for the various rudder and wing controls, in many cases doubling them as a matter of precaution.

It is becoming common practice, too, to mount all moving parts in ball bearings. A good example is found in the Maurice Farman biplane, in which the steering wheel has a fore-and-aft motion for the front elevation rudder, with the use of ball bearings, and a rotary motion for the lateral rudder, also on ball bearings. The same is found on the Voisin, which has now abandoned its front elevation rudder.

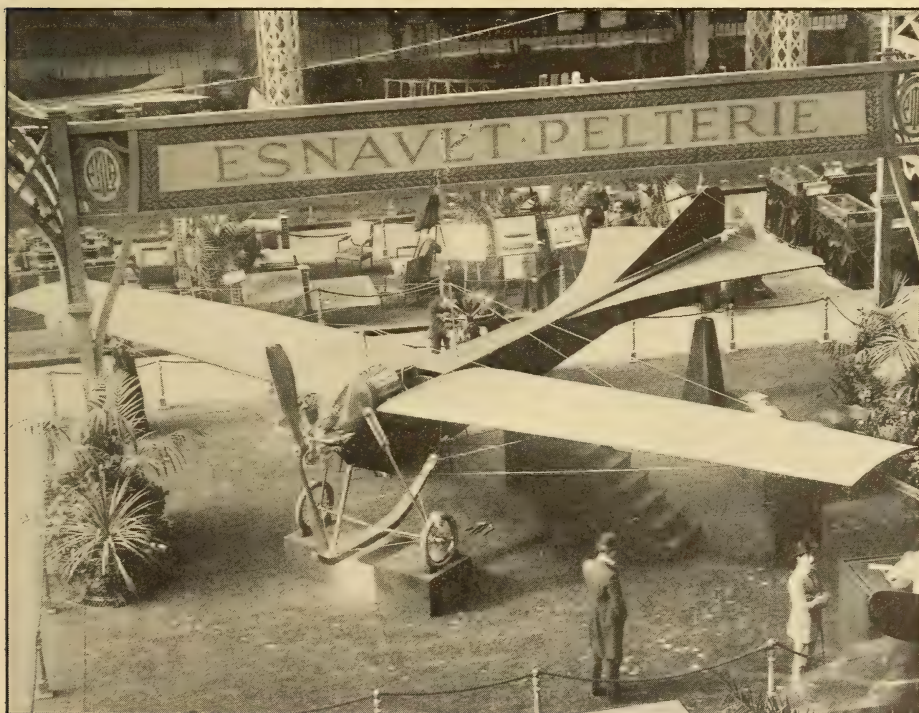
Another example is shown on the Esnault-Felterie, a monoplane on which a lot of practical work has been done during the past summer, and which now has a certain resemblance in its main features to the well-known Antoinette. Here the framework, including that for the lateral and vertical rudders, is entirely of steel tubing. On the

lower longitudinal frame member is mounted the lever for operating the wing warping, the lever being on ball bearings and the connection up to the driver's hand being by means of a stout steel column. Without being unnecessarily heavy, there is as great a margin of safety as in the best-built automobile steering gear.

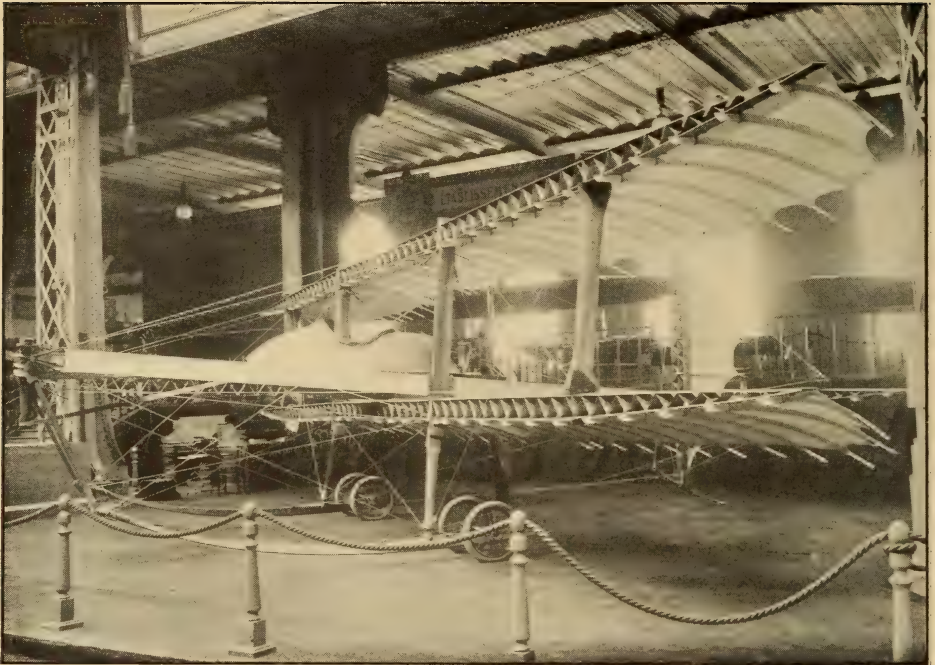
The rivalry between the monoplane and the biplane has not diminished, and does not appear likely to do so. In this particular the different parties retain their old positions. In spite of reports of monoplanes being built by biplane constructors, none are shown at the exhibition; it must be conceded, however, that there are a greater number of new monoplanes than biplanes. Triplanes are entirely absent, while helicopters and ornithopters are a minus quantity in both the theoretical and practical sections.

Of the new machines shown, undoubtedly the one attracting the

greatest amount of attention is the biplane produced by Louis Paulhan. The ex-Farmanite prefers to have his apparatus known as a *machine a voler*—a flying machine—rather than a biplane, although it undoubtedly enters into this latter class. The two main supporting surfaces, entirely flexible, have a spread of 40 feet, the total bearing surfaces being 322 square feet. Each of the transverse beams forming entering edges is made of two flat members joined at their extremities and united along the whole of its length by inclined divisions, forming a kind of truss-work and presenting a large series of tetrahedral cells to the passage of the air. Paulhan declares that he has greater strength with this structure than with a solid or hollow beam, while the cells give a certain amount of sustentation and effectively prevent drift. The ribs of the wings are attached to the lower of the two mem-



ROBERT ESNAULT-PELTERIE MONOPLANE, WITH FRAMEWORK MADE ENTIRELY OF STEEL TUBING



THE NEW PAULHAN BIPLANE, WITH CELLULAR FRAME CONSTRUCTION

bers, and, as there is no other transverse member, they are naturally flexible. The canvas is laid over the framework thus formed and is secured by a hook near the rear end of each rib; thus, after releasing the hooks, the canvas can be furled like the sails of a ship.

Four solid uprights, of oval section, with their thin edge forward, unite the two transverse beams. An elevation rudder is carried at the front between two parallel beams, forming a fuselage built up in the same way as the transverse wing beams. These longitudinal members, however, are naturally covered with canvas. At the rear and between the two longitudinal members is the vertical rudder, of considerable height but rather limited depth. Behind it is the horizontal tail member, the framework of which is composed in the same way as that of the main wings. The tail is mounted on chrome leather hinges, to allow of variations of the angle according to

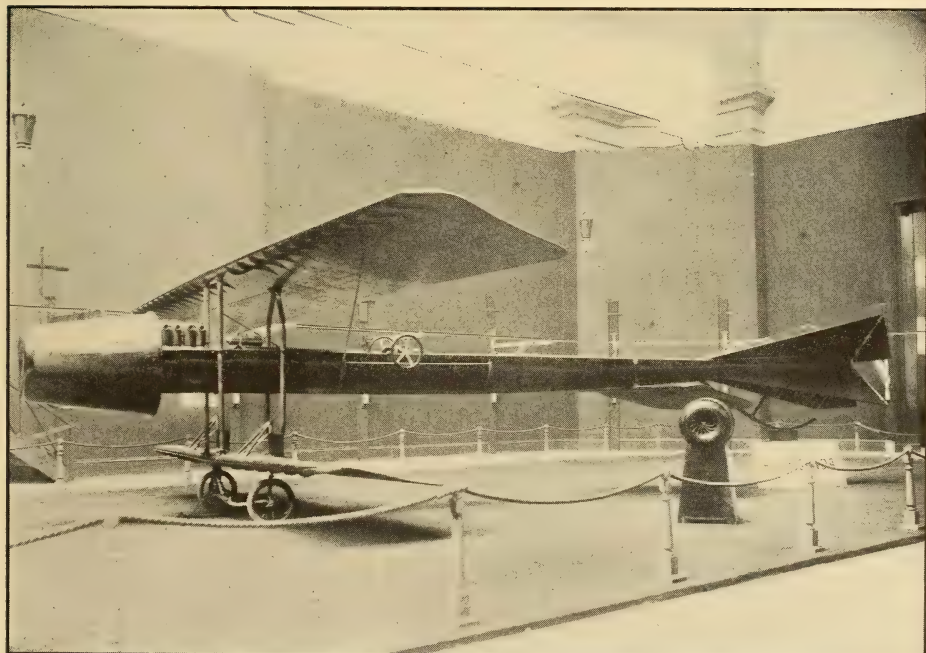
the load that is carried. The front elevation rudder is also hinged on chrome leather, the hinges being held between several layers of wood and leather bolted together. Control of the front elevation rudder is by means of a steering wheel and horizontal connecting-rod. It is most probable that Paulhan will secure lateral stability by warping of the wings, although he is not yet fully decided on this point. The landing chassis is a combination of skids and wheels, obviously the production of a man who has done considerable flying. The pair of wheels near the end of each skid are directly under the entering edges of the main planes, the skids extending forward as far as the front of the elevation rudder and connected up to the front edge of the fuselage. Chrome leather hinges are employed throughout in the connections of the landing chassis.

A most unusual feature is an entirely independent and suspended body carrying the pilot, his passenger and

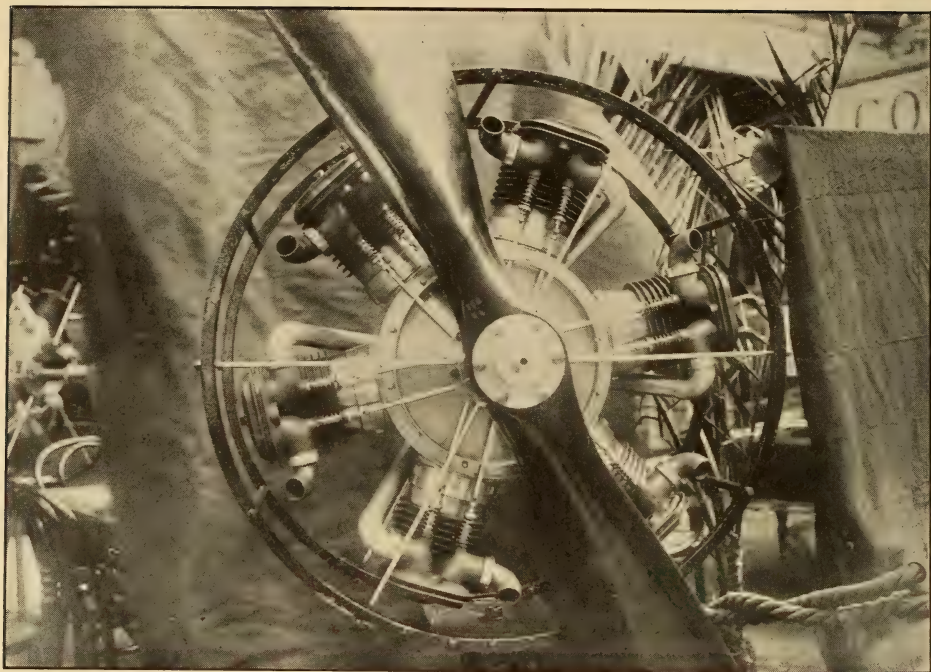
the motor. It is practically the reproduction of a two-passenger torpedo body as used on automobiles. The pilot and his passenger sit side by side, while the motor is placed at the rear of them and outside of the body. The whole is suspended in the aeroplane by a triangular system of steel cables. The motor is a seven-cylinder, 50 horse-power Gnome, driving a wooden propeller of 105 inches diameter. The total weight of the aeroplane, including motor, is 880 pounds.

Another interesting machine is a biplane with all-wood wings and a turbine instead of screw, shown by Henri Coanda. The fuselage has a very close resemblance to that of the Antoinette, being a pure boat type, with the pilot amidships and the motor forward. Instead of a sharp nautical bow, however, this is capped by what might be compared to a huge thimble, within which is the turbine driven by the four-cylinder vertical motor. The inventor declares that he can get a higher efficiency

from his turbine than from the best screw propeller built. This point, however, remains to be decided by practical tests. The main wing is about $2\frac{1}{2}$ feet above the fuselage, and not attached to it directly, as on most monoplanes. Below the fuselage and attached to the main bearing surface by two pairs of uprights is a smaller bearing surface, the presence of which allows the machine to be considered as a biplane. Both wings are built up with transverse members and ribs and covered with highly polished veneer. At the rear and under the fuselage is a horizontal plane, and the extremity of the fuselage terminates in four inclined triangular planes in the form of an arrow head. The extremities of these planes are pivoted and form both lateral and elevation rudders. The idea of an all-wood covering for the wings is rather favorably received, for it is recognized that canvas and other cloth has its limitations. The turbine apart, there seems to be no reason whatever why the Coanda



THE COANDA BIPLANE, WITH WOOD VENEER PLANES AND ENCLOSED TURBINE PROPELLER



FILTZ SIX-CYLINDER REVOLVING AIR-COOLED MOTOR

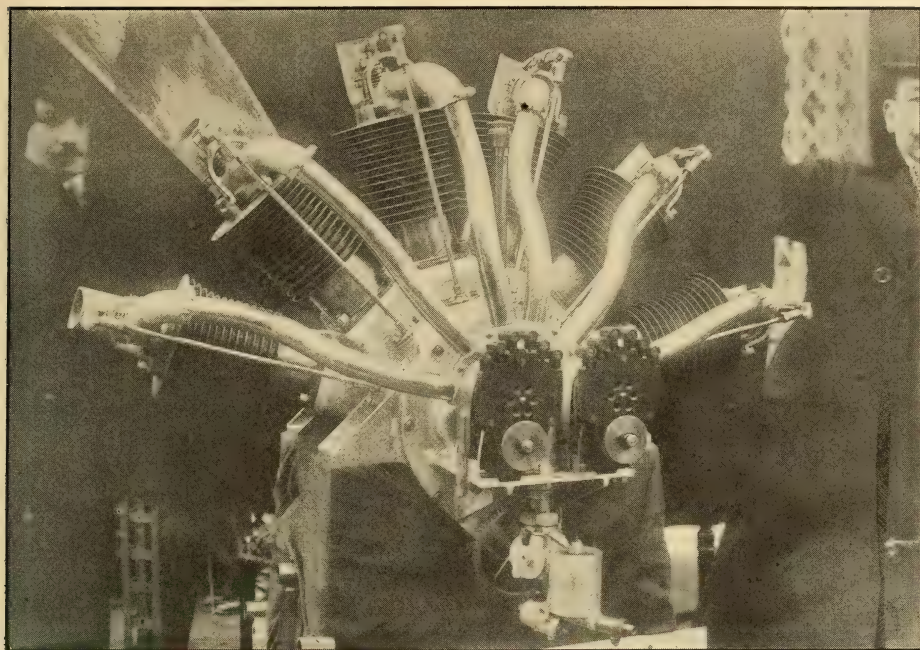
should not be a most successful type of aeroplane. Its lines are certainly pleasing.

The Sloan bicurve aeroplane is put forth as a machine with which serious accidents are impossible. The lower plane is composed of two wings attached to a central fuselage, forming a dihedral angle and having a similarity in their shape and angle with those of the Antoinette. These planes, on which the inventors rely for sustentation, are surmounted by a curved stabilizing surface the extremities of which approach the lower wing tips. The claim is made that, in the case of a gliding descent, the upper surface offers a lateral stability equal to that of a parachute. The rear offers nothing in particular, being composed of two horizontal planes with their extremities pivoted to form elevation rudders. They are surmounted by a single lateral rudder. The motor is in front and drives two tractive screws by means of chains running in tubes. The

pilot's position is well to the rear within a kind of tonneau mounted within the fuselage.

There are not many attempts to use two propellers on an aeroplane. In addition to the Sloan bicurve and the well-known Wright, it is an arrangement that is found only on one other machine—the De Coster—a monoplane with a fish-shaped fuselage, with the screws carried behind the wings and driven by chains.

There is a wealth of novelty in the motor section of the exposition. Not only have all the leading motor-car constructors given attention to this branch of engineering, but smaller firms and men with ideas have come forth with new motors. We are as far as ever from arriving at a definite type of motor for aerial work. Among the well-tested models are such widely differing types as the Gnome 14-cylinder, revolving air-cooled and the Barriquand & Marre four-cylinder, vertical motor-car type, as used on the Wright machine. Be-



THE LEMASSON SIX-CYLINDER RADIAL MOTOR

tween these are four, five, six and eight-cylinder models on more or less standard lines.

For the Blériot monoplane a four-cylinder motor has been produced with its head downwards and its crankcase above. Although metal has been pared away to the limits of safety, there is nothing extraordinary in the design, and the inverted position has been adopted in order to bring the centre of gravity lower.

There is an unusual departure in the Oerlikon four-cylinder, horizontal motor with ball-bearing crankshaft, connecting-rod ends, wrist pins and valve-operating mechanism. The crankcase is entirely open, to facilitate cooling, and oil is delivered only to the cylinder walls. It is declared that the lubricant splashed out from the cylinders is sufficient to supply the ball bearings, and that, working

in the air, there is no need for protection against dust.

Another original motor is the Weisz, which has fixed pistons and vertical reciprocating cylinders, which are naturally air-cooled. The crankshaft is overhead, and the connecting-rods are attached to the heads of the cylinders instead of to the pistons. Valves are in the piston head, operated by a camshaft under the base of the motor and parallel with the main shaft.

On the Onne motor advantage has been taken on the usually waste space between radial cylinders to carry radiator tubes. The motor has seven cylinders radiating from a circular crankcase; they are water-cooled and connected together by rings of flat-gilled tubes. In addition, a very small amount of water is carried in a tank.

THE CAPE COD CANAL

By R. P. Getty

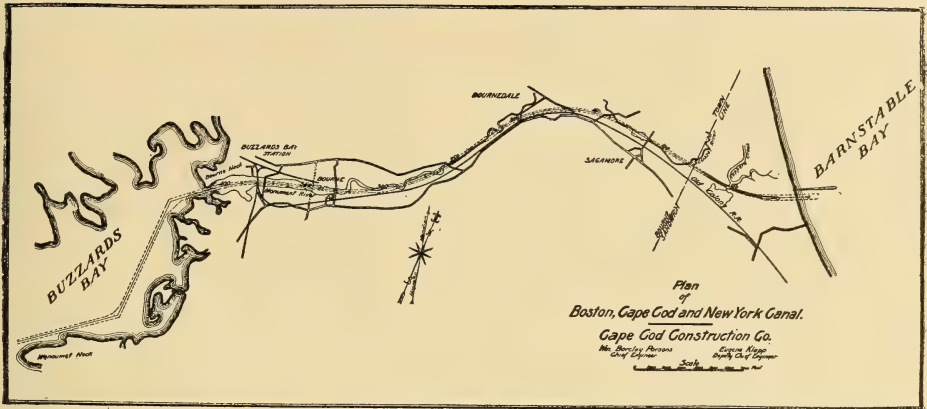
THE idea of building a canal through the narrow neck of land on Cape Cod, which separates Barnstable Bay in the present town of Sandwich from the Buzzards Bay in the present town of Bourne, is one that is almost coeval with the settlement at Plymouth. The Pilgrim Fathers, anxious for commercial intercourse with the other colonists along the shore of Long Island Sound, experienced very early in their history the many dangers to their frail shallops that lay in the long voyage around the end of the cape, and looked about for a possible way to circumvent them. The opportunity was presented not far from home. At the waist line of the sandy peninsula, and not more than eighteen miles distant from Plymouth settlement, a small stream, called the Scusset River, rose about two miles inland, and then flowed northerly through low lands and sand dunes to the waters of Barnstable Bay. Nearly opposite it, and on the other side of the cape, another stream, called the Manomet or Monument River, followed a winding course for three or four miles, and then emptied into Buzzards Bay. The isthmus that separated these two waters was not more than a mile and a half in length. By transporting their goods up the Scusset River to its head, and then carrying them the short distance by land until they reached the navigable waters of Manomet River on the opposite side, the Pilgrims were able to make the journey southerly in less time, and without incurring any of the perils of treacherous shoals and frequent fogs which went with the long passage around the end of Cape Cod's stretch of sand.

In 1627 the Plymouth colonists had already established a trading post at Manomet, near the mouth of the Manomet River, which became one of much importance, not only as affording facilities for trading on the south side of the cape, but for dealing with the Narragansett country and the whole shore of Long Island Sound. Historical records show that the Pilgrims carried on their first business relations with the Dutch at New Amsterdam in this manner.

The Plymouth colony grew more ambitious as its brave little band of settlers increased in size and prosperity. Better and larger boats were constructed that were unable to navigate in the waters of this short route. So the advisability of building a canal was considered. As early as 1678 a mention of it was made in the diary of one Samuel Sewall, who in October of that year noted thus:

"Mr. Smith, of Sandwich, rode with me, and showed me the place which some had thought to cut for to make a passage from the south sea to the north. He said it was about a mile and a half between the utmost flowing of the two seas."

No real action was taken, however, until 1697, when the necessity for such a canal came up in the General Court of Massachusetts, and a committee was appointed consisting of John Otis, of Barnstable, Captain William Bassett and Thomas Smith, of Sandwich, to view a place for the passage. This committee made no report and the project was abandoned. Many similar efforts have been made to build the canal through this narrow neck of Cape Cod in the two hundred years and more that have since

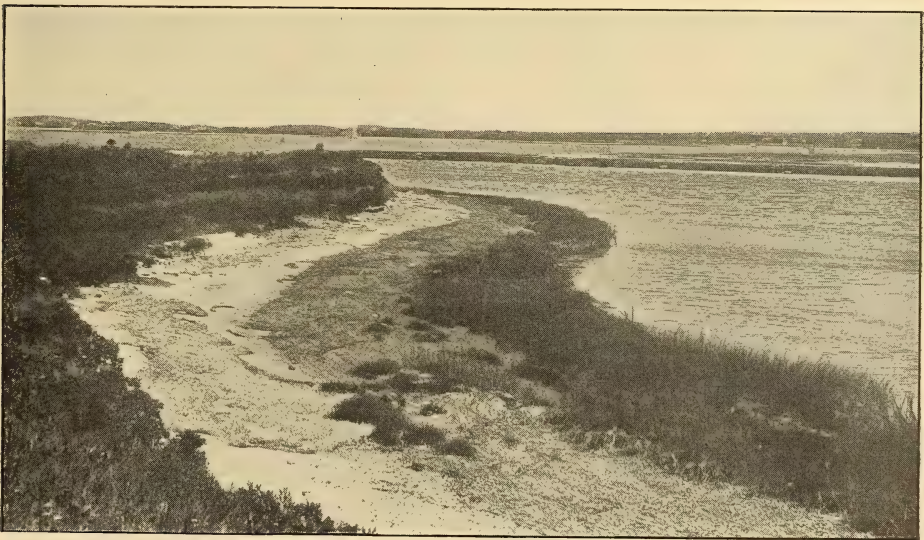


MAP OF THE ROUTE OF THE CAPE COD CANAL

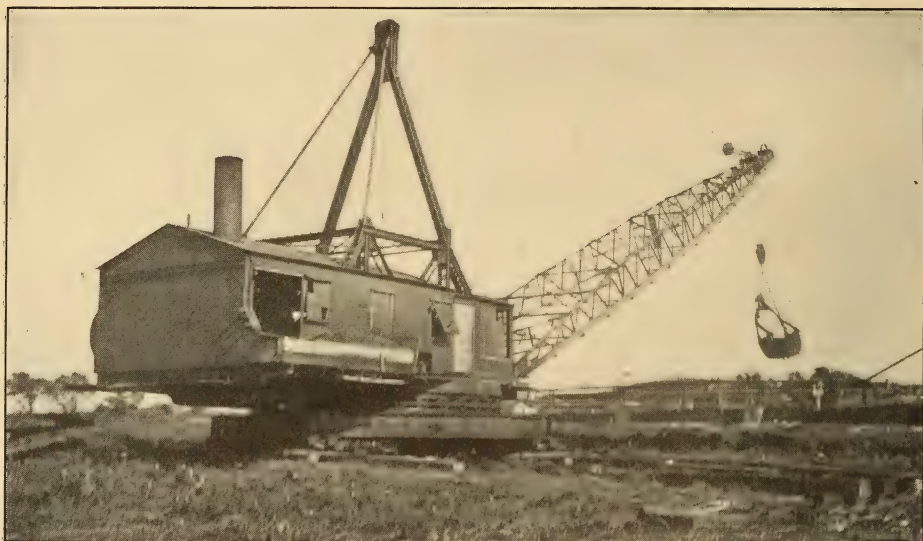
elapsed. So far every attempt has failed. In the early Colonial years the time had not arrived for such a great undertaking. Wars, foreign and domestic, interfered with the scheme on other occasions. Then funds were not forthcoming at the proper time to finance the work. Last, but not least, grave doubts always existed in the minds of its promoters as to the practicability of the proposed waterway and of its ultimate success. The latest effort is now being carried on under the control of the Boston, Cape Cod and New York Canal Company, a cor-

poration chartered by virtue of the statutes of the Commonwealth of Massachusetts, passed June 1, 1899, and July 17, 1900.

Mr. DeWitt C. Flanagan, of New York, was largely instrumental in obtaining this present charter. Through his influence Mr. August Belmont and other gentlemen formed the Cape Cod Construction Company, which has agreed to build and finish the new waterway for the sum of \$11,900,000, and to take its pay for so doing in securities of the Canal Company. One hundred shares of its stock have been



ENTRANCE TO THE CANAL, BUZZARDS BAY



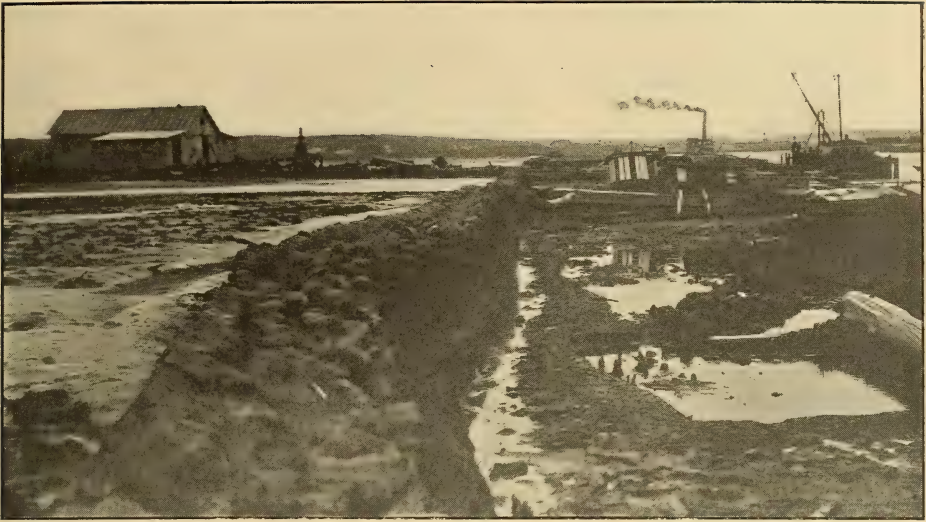
LAND EXCAVATOR AT WORK ON "DIVIDE"

retained by the latter company, and paid for in cash, in order to comply with the Massachusetts statutes. The officers of the Cape Cod Construction Company are August Belmont, president; J. W. Miller, first vice-president; A. Lithgow Devens, second vice-president; Wm. Barclay Parsons, chief engineer; U. A. Murdock, secretary, and J. J. Coakley, treasurer.

Early in last year the Cape Cod Construction Company made a contract with the Degnon Contracting Company to do the excavating, build new railroad approaches, change the grade of highways, etc., and on June 22, 1909, at the village of Bourndale, midway between the terminal of the proposed channel, Mr. Belmont, at the invitation of the contracting com-



THE WAKE OF THE LAND EXCAVATOR. THE WAY IN WHICH "DIVIDE" IS LEFT FOR DREDGES



GENERAL VIEW OF WORK ON CANAL, LOOKING WESTWARD

pany, turned the first shovelful of dirt, and started the actual work of building the canal.

The valley through which this new waterway is to pass extends in length a little less than eight miles from the waters of Barnstable Bay to those of Buzzards Bay. The general direction is southwest. The bottom of the valley rises to a height of twenty-nine

feet, the greatest elevation being at a point five miles distant from Buzzards Bay. From this point it descends to Barnstable Bay, there being a difference of about two feet in height between the two extremities, the latter being the higher. The soil of the valley is mostly gravel, sand and loam. There is an absence of quicksands and boulders.



LOOKING EAST TOWARD MOUTH OF CANAL IN BARNSTABLE BAY

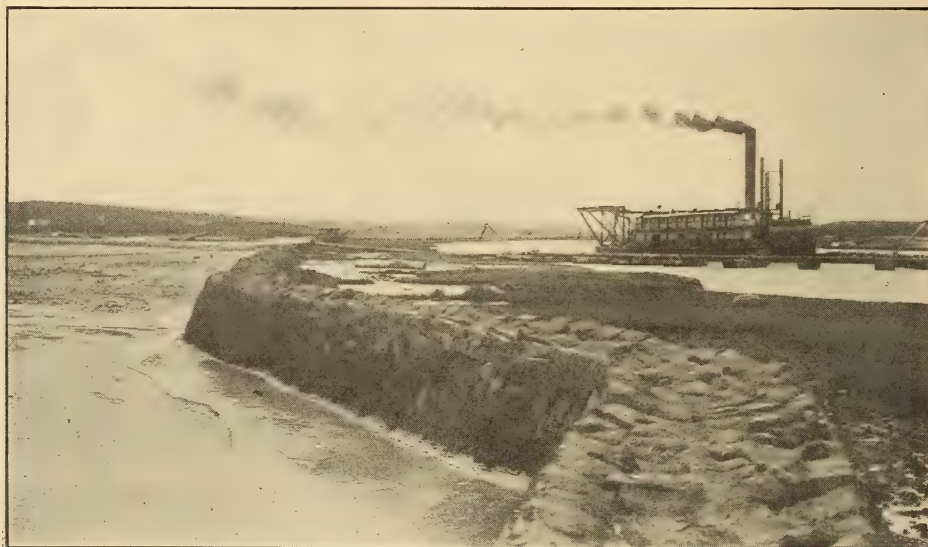


BUILDING SOD LEVEES AT THE SANDWICH END OF THE CANAL

The present work necessitates a cut through the land just described. The excavations will also be extended two miles under water at both ends, thus making a sea level canal twelve miles long.

The plans of the Canal Company call for a channel in Buzzards Bay, leading to the mouth of the Monument River, which shall be two hun-

dred and fifty feet wide and twenty-six feet deep at low water. The one leading from Barnstable Bay to the entrance at Sandwich will be three hundred feet wide and of extra depth. The channel of the cut will be one hundred feet at the bottom, and not less than two hundred and fifty feet wide at the narrowest surface point. The depth will be twenty-five feet.



A SOD LEVEE ALONGSIDE OF THE CANAL

At the Sandwich terminus it is also proposed to make a bottom width of three hundred feet for the distance of three thousand feet. This will allow the tows in passage through the channel to stop and readjust their towlines before entering into the waters of Barnstable Bay in case of bad weather outside. There are also to be three passing places, the bottom width of which varies from one hundred to two hundred feet for the distance of eighteen hundred feet, which will permit two vessels to pass each other.

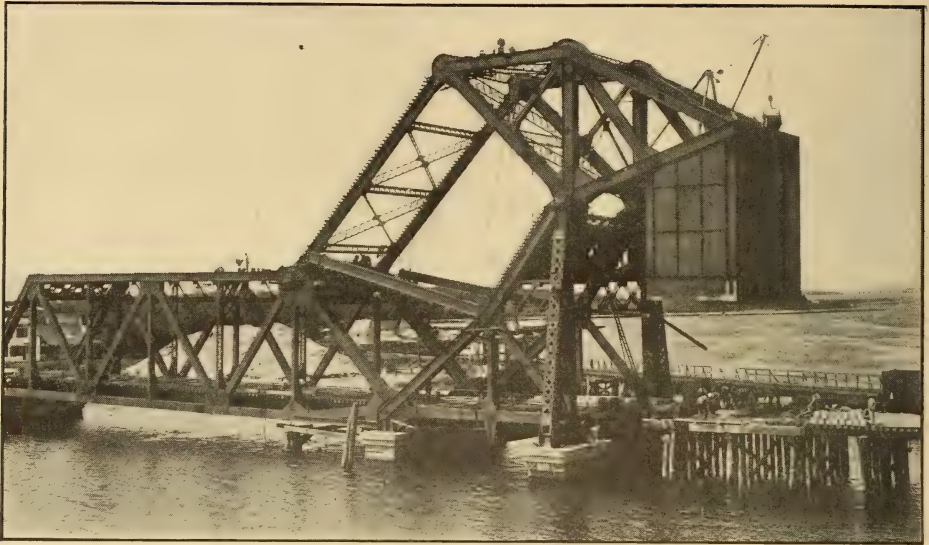
The manner of protecting the sides of the canal from the wear and wash of the tides and passing vessels has not yet been fully determined. In some places the natural slope and a levee of sod and mud will be enough. In other sections granite riprap and cement reinforcement will probably be employed.

The canal, when completed, will be lighted by electricity from one end to the other. At the entrance at Barnstable Bay the government has already arranged for the erection of a light-house. Range lights and other aids to navigation will be placed along the route wherever necessary.

Much has been done in actual work since its beginning on June 22, 1909. Contracts have been made with the Pennsylvania Steel Company for bridge steel work, and with Holbrook, Cabot & Curtis for bridge foundation work. Rights of way have been acquired, and, as the Canal Company intends to control a six hundred feet strip on both sides of the channel its entire length, land for this purpose is being secured. The company has purchased an administration building at Sandwich, and other buildings have been obtained at Buzzards Bay. At this latter place the construction of the canal makes necessary the changing of the tracks of the New York, New Haven and Hartford Railroad between that village and Bourndale, so that the railroad shall cross the new channel but once in its route. Accordingly a large bascule lift bridge of the Strauss pattern has been in course of construction for several months over the Monument River and is now practically completed. The iron work rests on three piers of concrete fifty feet long and is six hundred feet long. The draw is one hundred and sixty feet in length. The surveys for the



GENERAL VIEW OF WEST END OF THE RAILROAD SWITCHING YARD, LOOKING EAST



STRAUSS BASCULE LIFT BRIDGE OVER THE MONUMENT RIVER, BUZZARDS BAY TERMINUS

tracks to Bourndale have been made, and within a few weeks the rails will be laid, and thenceforth all trains, bound to and from Provincetown way, run down the south side of the Monument River, instead of the north side, as at present.

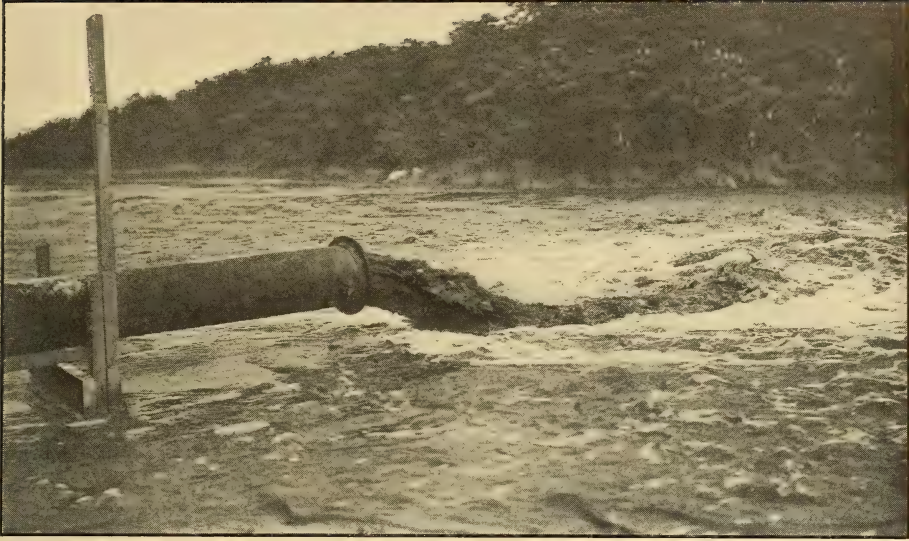
The approach channel at Buzzards Bay is being dug out by three dredges; and near the new bridge a suction

dredge, capable of taking out 2,000 cubic yards of sand and mud a day, is deepening the mouth of the Monument River.

At the Sandwich end even greater activity is noticed. Here two large hydraulic dredges, the General MacKenzie and No. 9, are removing nearly 20,000 cubic yards of spoil daily through the Scusset marshes. At this



DREDGE DIGGING OUT CHANNEL AT MONUMENT RIVER, BUZZARDS BAY



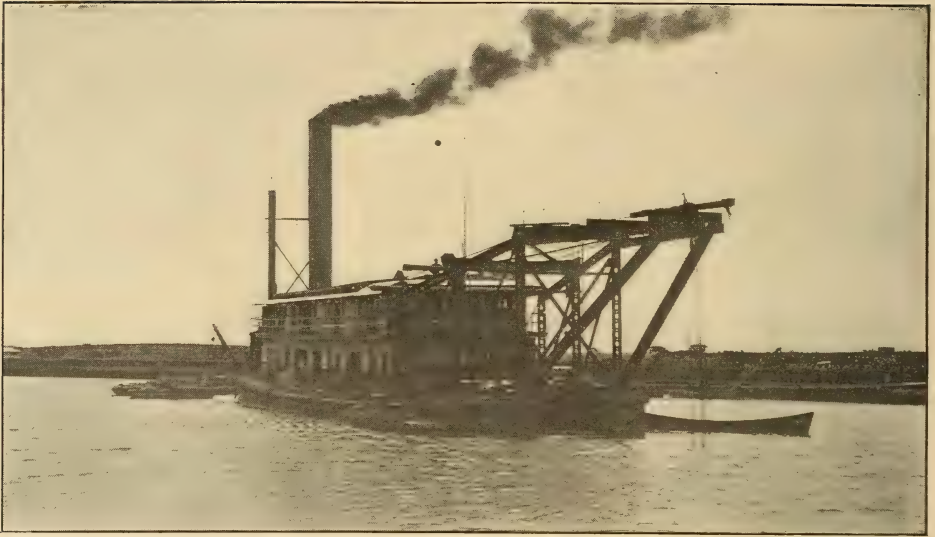
BUZZARDS BAY END OF 24-INCH PIPE OF SUCTION DREDGE ON MONUMENT RIVER, DISCHARGING MUD

terminus, also, has been constructed a breakwater of granite which is 3,000 feet long and sixty feet wide. This will serve as a protection from the north and northeast winds and storms which are prevalent in all this section. Another breakwater to guard against drifting sands is also contemplated.

In the isthmus between the heads of

the two rivers, two land excavators are digging out to a depth of five feet the soil and roots of trees in the course of the channel, so that the dredges may have easy work when this point in the operations is reached. Each of these excavators is able to take out from 700 to 800 cubic yards of material in a day. Plans have been pre-



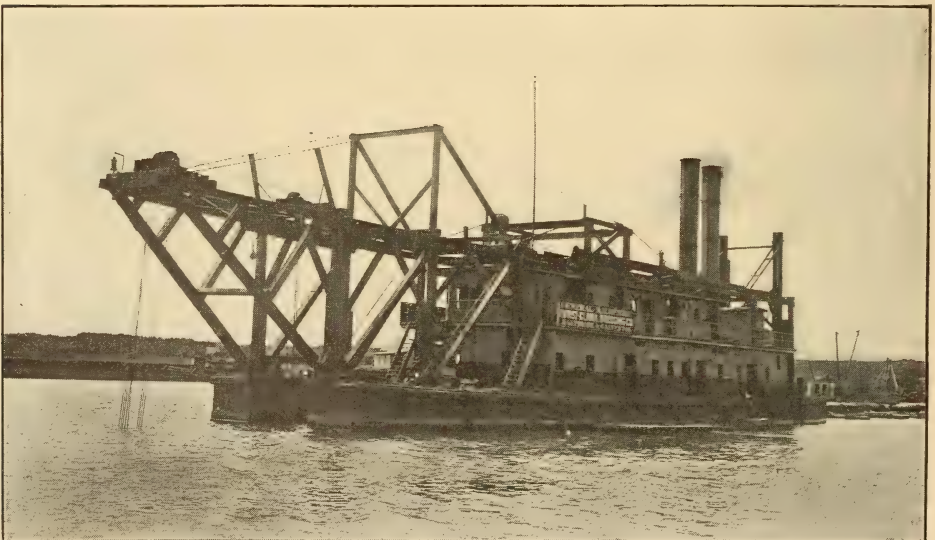


SUCTION DREDGE NO. 9 AT WORK ON THE SANDWICH END OF THE CANAL

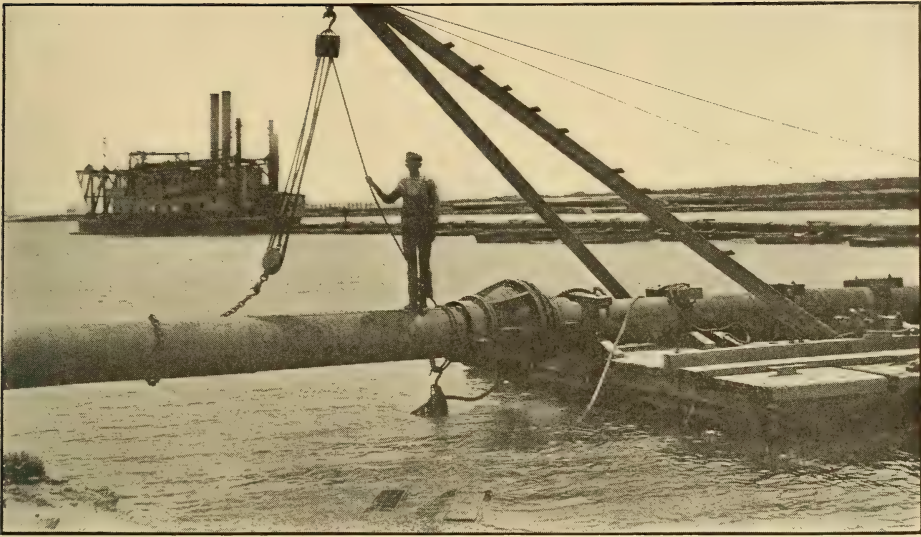
pared for a highway bridge to be built a short distance west of the present Bourne railroad station, and other bridges at Sagamore and Bourndale stations are under consideration by the town highway commissioners and the Canal Company.

The completion of the Cape Cod Canal will be an important thing for the commercial activities of the East-

ern, Middle and Southern States, for it is estimated that it will save seventy-five miles and one hundred and forty-five miles, respectively, in distance over the present inside and outside routes between Boston and New York. It will also lessen the dangers to many lives and vessels during the frequent Eastern and Northeastern storms of winter which have made Cape Cod's



THE DREDGE GENERAL MACKENZIE AT WORK IN CHANNEL, SANDWICH TERMINUS



DISCHARGE PIPE OF DREDGE NO. 9 AT SANDWICH END OF THE CANAL

shores the most perilous of the United States.

According to figures that have been compiled by the Canal Company, 2,131 vessels were wrecked along Cape Cod from 1845 and 1903, of which 908 were a total loss. Then complete crews disappeared, and, in addition, about 700 fishermen and sailors lost their lives. It is risks such as these that are charged for heavily by the marine underwriters, and so great will be the eliminations by the new channel that it has been calculated that there will be a saving of from ten to twenty-five per cent. on the insurance premiums.

How much this will amount to annually may be imagined when it is stated that over 40,000 vessels round Cape Cod every year.

That the transportation facilities will also be greatly benefited by the opening of the canal there seems no doubt. Statistics that have been prepared show that over 25,000,000 tons of merchandise are annually carried around the Cape, and include the following items:

	Tons.
Coal	9,000,000
Stone	300,000

Nova Scotia plaster.....	250,000
Oil	200,000
High-class merchandise ...	2,000,000

The balance is made up of other merchandise of various kinds.

In addition, there are thousands of tons that are carried by the railroads to and from the same points as the water transportation.

The opening up of the canal must necessarily change all this. It will make many commercial centers more accessible. The distance will be shortened. The dangers of the long route will be eliminated. The freight charges will be correspondingly cheaper. It is likely, too, that very much of this merchandise that goes now by land, or partly by land and water, will be carried exclusively through the new channel.

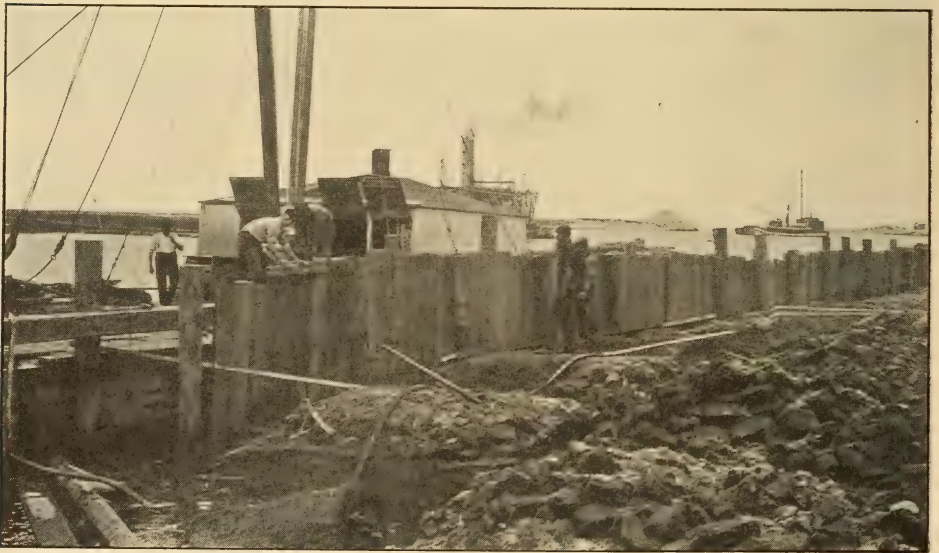
In the passenger service there will likewise be benefits the moment the new waterway is opened up to travel. The number of passengers between New York, Southern and Eastern points by water is to-day over 500,000. This amount must be greatly increased through the opening up of the canal, as it will be a great convenience to the public when it can leave New York late in the evening of one day

and land at Boston and other points the next morning, without any of the delays now necessary by reason of the change to cars at Fall River, New Bedford and the other ports of call of the boats that ply on Long Island Sound.

The canal will also have its uses in time of war. For a long time there has been need of some speedy means by which warships could be sailed from such ports as Boston, Newport and New York through a deep channel. To-day the large battleships must sail the outside route around the

drawing thirty-four feet of water, which would permit the largest type of battleship to sail through it in perfect safety.

Already persons interested are considering the availability of the new canal as a waterway. On the route is located the carworks of the Keith Car & Manufacturing Company, a concern that does a large and increasing business and one that employs hundreds of men. Just as soon as the channel is completed down to the shops of this company, it is expected that it will use the same for the car-



BUILDING A BREAKWATER FOR WHARVES AT CANAL TERMINUS AT SANDWICH

Island of Nantucket, for the Pollock Rip passage is not deep enough for vessels drawing over twenty-one feet of water. Besides this, the Pollock Rip passage is shoaling rapidly and will shortly be unsafe for vessels of small draft unless the government proceeds to deepen it. The estimated cost of so doing is \$3,000,000, and a request by the merchants and steamship men of Boston has already been prepared, asking for an appropriation for this purpose, and will be presented to the next session of Congress. For much less money the Cape Cod Canal could be made navigable for vessels

riage of all their coal and raw material.

The New Haven Railroad has already taken steps looking forward to the completion of the new waterway. This company recently acquired the Commonwealth wharf at South Boston, and it is the intention of the company to use it for a line of steamers, consisting of the *Bunkerhill*, the *Old Colony* and the *Massachusetts*, that will ply between New York and Boston. The Merchants and Miners' Transportation Company, the United Fruit Company, the Savannah, Philadelphia and Clyde steamship com-



BREAKWATER AT BARNSTABLE BAY

panies, will also use the new route.

A short account of the different projects for building the Cape Cod Canal may prove interesting, for it shows how far ahead of the times the old New Englanders were in the matter of inland waterways.

The first effort in 1697 proved abortive, as might have been expected. The struggling Plymouth Colony was in no financial position to seriously contemplate such a stupendous undertaking.

Nothing was done after this attempt until 1776, when the General Court of Massachusetts appointed James Bowdoin, William Sever, Colonel Freeman, Brigadier Godfrey and a Mr. Cushing to report on the advisability of such a canal. This committee employed Thomas Machin, an engineer in the service of the Colonial government, who began a survey for a route. Owing, however, to the breaking out of the War of the Revolution, Mr. Machin was recalled by General Washington for more pressing duties, and the second attempt to build the canal ended in failure.

In March, 1791, the subject was again agitated, and the newly organized State of Massachusetts ap-

pointed Azor Orne, Thomas Russell, William Sever and Thomas Davis to consider the practicability of the proposed channel. This committee employed James Winthrop and John Hills to prepare the surveys, but again nothing was accomplished.

In 1798 a petition for consideration of the project came before the Legislature once more, and again in 1801 and 1803, but, like the others, proved abortive.

During the war with Great Britain in 1812 the isthmus between Sandwich and Buzzards Bay was used for the transit of merchandise, which this way avoided the dangers of capture by the enemy.

In 1818 the scheme was revived once more by Israel Thorndike, Thomas H. Perkins and others, who employed Laommi Baldwin to survey the route. Mr. Baldwin went to work and prepared surveys and soundings that were very comprehensive, but nothing further was done in the matter.

In 1824 the project appeared for the first time in the United States Congress. Mr. Lloyd, of Massachusetts, submitted to the Senate a resolution in which the Committee on Roads and Canals was requested to ask the

President of the United States to cause the necessary survey to be made, and to consider the advisability of this short cut across Cape Cod for war vessels. After a protracted debate in Congress an act was passed requesting the President to cause the necessary surveys, plans and estimates to be made of such roads and canals as he might deem of National importance in a commercial or military way. Under this act, and in accordance with instructions drawn up by the Board of Internal Improvement, the ground between Barnstable Bay and Buzzards Bay was surveyed under the direction of Major P. H. Perault, of the United States Topographical Engineers in 1825. These plans were laid before Congress. Another act was passed in 1827 and other plans drawn up by the Board of Internal Improvement. Again, notwithstanding the interest of the Federal Government, nothing was accomplished beyond the mere matter of surveys.

During these several times that the question of building the canal was before these different legislative bodies, it must be remembered that the importance of such a waterway was not apparent as it is to-day. Its usefulness

was conceded, but not its necessity. It was not until just before the Civil War that there seemed a strong probability that at last the much-talked-of cut across Cape Cod would become a reality. In 1860, Governor Banks, of Massachusetts, referred to the necessity of the canal in his message. This immediately revived the subject again with increased vigor. The Legislature appointed a committee consisting of Tappen Wentworth, Amos A. Dannel, George Foster, William Nye, Jr., R. A. Pierce, George Odiorne and G. M. Fiske. The report of this committee suggested that the United States should furnish a large portion of the funds necessary to build the canal, and in accordance with the report a letter was sent to the superintendent of the United States Coast Survey, asking if the United States Commissioners of Boston could not aid the committee. Professor A. D. Bache, the superintendent of the Coast Survey, sanctioned the suggestion, and at his instigation the officers of the Coast Survey were engaged to make new surveys and soundings.

In 1861 another committee, consisting of G. M. Fiske, George A.



ENGINEERS AT WORK AT THE SANDWICH TERMINUS

Shaw, R. A. Pierce, Ansel Lewis, John S. E. Rogers, George H. Brown and Samuel O. Whitmore, was appointed by the Legislature. Henry Mitchell was placed in charge of the observation of the tides, etc., and the plans and surveys were revised by the officers of the Coast Survey. The results of this work were submitted to the Legislature, but just at that time the country was engaged in all the excitements of a Civil War, and again the efforts were abandoned when the outlook for the canal had never seemed so bright.

Nothing was done for twenty years after this, although the necessity for a channel across the Cape was yearly becoming more manifest. In the year 1883 a charter was granted by the Commonwealth of Massachusetts to a corporation known as the Cape Cod Ship Canal Company, and, acting under its provisions, Mr. Henry M. Whitney had exhaustive borings and new surveys and plans made. Mr. Whitney, who practically controlled the company, let the contract for building the waterway to Mr. Frank M. Lockwood, who agreed to take his pay in

securities of the company, amounting to ten million dollars. Mr. Lockwood interested Mr. Quincy A. Shaw, a capitalist, in the enterprise, and once more it looked as if the canal would be finally built. Mr. Shaw, however, failed to supply the working capital, so Mr. Lockwood was obliged to make an assignment. Mr. Thomas L. Livermore, the assignee, in 1884, obtained an amendment of the charter, and was able to get some English capitalists interested in the scheme. The same ill luck followed this attempt. Baring Brothers, of London, failed. Other financial calamities came, and, although about one mile of the proposed channel was dug in these vain efforts, the enterprise went no further.

There are still persons who are skeptical as regards the undertaking of the present Canal Company; but so many assurances of final success have been made, and the preparations for the great work are so complete, that it must be taken for granted that this boon to humanity and aid to commercial progress, the Cape Cod Canal, will, in two or three years at most, become an established fact.



ASPHALTS AND BITUMENS IN ELECTRICAL WORK

By C. Toone

ASPHALTS and bitumens have, of late, attained great importance as electrical insulating materials for the highest grade work as well as for such heavier, rougher applications as cable laying. A brief sketch of the nature of asphalt and its use in the present connection may therefore be acceptable, particularly as the term "asphalt" is so frequently associated solely with the paving operations using this material. The same chemical inertness and protective and preservative properties which made bitumen the mummy-embalming material of ancient civilizations are largely responsible for its present-day applications in the electrical industry.

Formation—Asphaltum, compact bitumen or mineral pitch, as the material is variously called,* is a product of decomposition of vegetable and animal matter and is, in fact, the ultimate product of the progressive natural evaporation and oxidation which successively converts naphtha to petroleum, mineral tar and hard bitumen or asphalt. The latter is geologically a quite recent formation, being mainly found in the later rocks. Naphtha occurs in nature as a limpid, colourless liquid; petroleum, the product of oxygenation of the less volatile portions of naphtha, is a thick brown oil; mineral tar is a more or less viscid, tarry material produced by the further evaporation and oxygenation of petroleum and finally "hard bitumen" is a hard, pitch black material with conchoidal fracture; it is solidified mineral tar considerably

further oxygenated, though it is probable that oxygenation is never complete in natural asphalt.

From the manner of its genesis it will be readily appreciated that crude asphalt contains more or less naphtha, light oils and heavier hydrocarbons and resins; in fact, traces of some or all of the various stages through which the original material passes to reach its final state.

Types—Besides the true *asphaltum* or hard bitumen, which is found native in very varying degrees of purity, there are other natural asphalts less valuable in the present connection, viz: *Elaterite*, *Gilsonite* and *Manjak*.

Physical properties—*Asphalt* (solid bitumen) is, when pure, opaque and black or brownish black in colour, is hard ($H = 2$) and gives a bright conchoidal fracture. Its specific gravity is 1.0 to 1.7 or 1.8; its melting point 90 to 100 degrees C. Its smell is bituminous and it is highly inflammable, burning with a bright flame and the evolution of dense and strongly bituminous smoke. Asphalt is waterproof and insoluble in alcohol; it may be dissolved in five times its weight of naphtha or benzol; ether is a solvent of the whole, except a small residue which is soluble in turpentine. Solution in the latter is the basis of one of the available means of refining natural asphalt. Alkalis and alkaline carbonates are other solvents of asphalt, while oils exert a rotting influence thereon.

By distilling solid bitumen various oils are obtained between 100 degrees and 300 degrees C. Of these the chief are *asphalt oil* (Thorpe, Völckel) a hydrocarbon oil varying

* Other less common denominations are "Jew's Pitch" and "Bitumen of Judæa"—names obviously attributable to the locality in which bitumen was first known.

in sp. gr. from 0.82 to 0.87, according to the temperature of evolution about 200 degrees C., and *petrolene* (Boussingault) boiling at 280 degrees C. and of sp. gr. 0.89. The residue from a 48 hours' heating of asphalt at 250 degrees C. is a black solid *asphaltene*, free from all volatile oils, which becomes soft and elastic at about 300 degrees C.

The chemical composition of average asphaltum in percentages is: C, 76 to 88; O₂, 2 to 10; H₂, 6 to 10; N, 1 to 3; ash 0.5 to 5.0.

The known sources of natural asphaltum are:

Cronwall; Fifeshire, Elie and Burnt-island; Lothians, East and West; Shropshire, Haughmond Hill. All British deposits are of quite minor importance.

Dead Sea—Very small deposits, but stated to be very pure.

Persia.

Harz Mountains.

*Limmer (Hanover).

Lobsann (Alsace).

*Seyssel (Rhône).

*Val Travers (Neufchâtel).

Trinidad—By far the most important deposits from the present point of view.

Barbados and Mexico.

Elaterite is frequently called "mineral caoutchouc" or "elastic bitumen," owing to its elastic and flexible nature; it is very soft and resinous, with a strong bituminous smell; in colour it varies from black to reddish or yellowish brown; sp. gr. 0.8 to 1.23. This material cannot be melted or dissolved, acids have no effect on it, but slow disintegration occurs under intense heat.

The chemical composition is usually C, 84 to 86 per cent.; H₂, 12 to 14 per cent.; O₂, trace; the chief known sources are Castleton (Derbyshire); St. Bernard's Hill (Edinburgh); Chapel Quarries (Fifeshire),

Montrelais (Nantes), and Woodbury (Conn., U. S. A.)

From the present standpoint elaterite is not important.

Gilsonite is one of the best known of the natural asphalts; it is very hard and brittle; melting point, 160 to 200 degrees C.; uses as later.

Manjak, another well known natural asphalt, is also hard, the Barbados variety being particularly hard and tough; melting point, above 200 degrees C.

The purest forms of natural asphalt are found in the pitch lakes of Mexico and, more especially, Trinidad. For electrical purposes Trinidad bitumen is by far the most important; the chief asphalt lake in Trinidad is of 114 acres extent, is roughly circular in form (about ½ mile diameter) and of unknown depth, though certainly exceeding several hundreds of feet. The surface being sufficiently rigid to bear mules and carts, if kept moving, quarrying becomes a simple matter. Though an average of 100,000 tons (about 2.4 x 10.6 cubic feet) have been quarried annually from this lake alone for a number of years past, the supply is insensibly reduced.

Less pure varieties are found in enormous quantities elsewhere; of these deposits the Val Travers bituminous limestone quarries are probably the most famous, but as noted above, these deposits, though admirable for paving purposes (indeed purer asphalts have to be brought to about this composition by the admixture of limestones), are too poor for electrical purposes, apart from such constructional applications as duct and cell lining, etc.

Refining—Crude asphalt is refined, i. e., freed from the more volatile oils contained in it and separated from mineral substances (mainly Ca CO₃) by:

(1) Melting and decanting the bitumen from the gangue;

(2) Boiling the crude material with water, the bitumen then running out in a molten state;

* The deposits at these places are "asphalt stones," i. e., limestones impregnated with bitumen; though exactly suited to paving requirements, these "stones" are of little value as sources of electrical bitumen, the asphalt content being only 7 to 20 per cent.

(3) Dissolving the Ca CO_3 , etc., by hydrochloric acid, leaving the bitumen unaffected;

(4) Dissolving the bitumen by turpentine, the impurities being then left as a precipitated sludge.

Uses—Asphalts are used in the manufacture of insulating varnishes

to brittleness otherwise existing in insulating materials (particularly paper) when completely dried in vacuo.

For the use as a conductor-covering material, replacing vulcanized rubber, bitumen is carefully refined and worked into a plastic mass, a certain

TABLE 1.—INSULATION RESISTANCES.

	Insulation R: Megohms per Mile.	
	At Maker's Works.	After Laying.
Vulcanized rubber cable drawn into earthenware pipes.....	4,700	1,000
Vulcanized bitumen cable drawn into earthenware pipes.....	150	25
Lead-sheathed paper cable drawn into earthenware pipes.....	600	10
Vulcanized rubber cable laid solid in bitumen.....	4,700	2,200
Vulcanized bitumen cable laid solid in bitumen.....	150	260

as well as "japans," but at present their chief uses in electrical work are: (1) The impregnation of hygroscopic, non-waterproof insulating materials (such as paper, hemp, etc.);

(2) The covering of such cables with a layer of solid dielectric, and subsequently their embedding in ducts run full of molten bitumen.

For all these purposes *Trinidad bitumen* is superior to the other varieties named above, owing to its greater tractability, as well as to its superior insulating properties. *Gilsonite* is mainly used to harden softer gums of lower melting point and is the base of most baking japans. *Manjak*, on account of its high melting point and other unfavourable properties, is very difficult to mix with other gums, but once thorough compounding is obtained, its use adds very desirable properties.

For use in varnish manufacture and for impregnating purposes the most carefully refined bitumen must be used; it is maintained at a temperature giving sufficient fluidity and then mixed with other varnish materials as required or absorbed by the material to be impregnated as the case may be. In all cases of impregnation, usually of cables or motor, generator or transformer coils, the material to be impregnated is thoroughly dried in vacuo and the hot bitumen then forced in under atmospheric pressure. By this means exclusion of all moisture and thorough insulation is ensured, while the bitumen further corrects the liability

percentage of sulphur being added; owing to its fluidity before treatment, refined bitumen must be at least partially "vulcanized" before application to the cable; the process of vulcanizing converts bitumen from a viscid fluid to a tough solid, mass. The copper of the cable must be first protected by a layer of tape saturated with *pure* bitumen, the vulcanized and sulphur-containing material being then applied in one or more layers by passing the cable through a die, round the back of which a pressure reservoir of prepared bitumen is arranged (the process of covering being exactly similar to that by which cables are lead-sheathed). The bitumen is given a preliminary "setting" by running the cable through long water-troughs after leaving the covering die. The whole is subsequently submitted to a "curing" process, which completes the vulcanizing of the bitumen. A covering of tarred rope or braid is usually added as a mechanical protection.

Bitumen insulation so applied possesses the valuable properties of high insulation resistance, high dielectric strength, flexibility, mechanical toughness, durability and cheapness. Vulcanized bitumen cables are less able to stand rough usage in laying than are vulcanized rubber cables; but once laid the former are very durable. Though vulcanized bitumen is lighter than vulcanized rubber its insulation resistance is inferior to that of the latter (see Table 1); hence the total weight of cables of equal

insulation resistance is about the same for both methods of construction.

Natural asphalt is only partially refined for use in cable laying in those "solid" systems in which the cable, of whatever type of insulation and armouring, is laid in wooden earthenware or concrete ducts on wooden or porcelain bridge pieces, the whole trough being then run full of molten asphalt. Such partial refining is quite sufficient, and beyond its economic advantage is the fact that the small percentages of natural oils left in the material greatly improve its toughness and flexibility, in case of gradual subsidence, and its adherence to the cable; should the filling material pull away from the cable after solidifying its utility is largely or wholly sacrificed. The high insulation resistance of bitumen affords a valuable safeguard against electrolytic corrosion of the cable by stray currents.

Semi-refined asphalt used as a trough-filling material is sufficiently flexible to follow most soil subsidences without cracking, though at the bridge sections, where the depth of bitumen is much reduced, failure occasionally occurs. Bitumen is supplied solid for use in cable laying; it is melted and poured at boiling heat

ough admixture of shale oil. Whereas the dielectric strength of bitumen averages 300 R. M. S. volts per mil, that of coal tar pitch is only some 50 R. M. S. volts per mil; the specific resistance of the latter is also inferior.

Insulation Resistance—In conclusion the data of Table 1 may be referred to as illustrating the remarks already made concerning the inferiority of vulcanized bitumen to vulcanized rubber as regards insulation resistance and the excellence of the "solid" bitumen system of cable laying as giving high working insulation. Where the figures of col. 4, Table 1, are greater than those of col. 3 the discrepancy is obviously accounted for either by careless works measurements or by the cable being damper at the works than when laid.

Costs—Assuming a 3-wire system with outers of 150 amperes capacity and a middle wire of 75 amperes capacity (at 1,000 amp. per sq. inch) the cost of a non-armoured cable (vulcanized rubber or vulcanized bitumen) would be about £450 per mile, while excavating for laying would cost, say, £175 per mile. The costs of protection (ducts, filling, etc.), street boxes and labour of laying being as in Table 2, the total cost of the various systems are as shown.

TABLE 2.—INSTALLATION COSTS PER MILE.

System.	Cost Cable + Excavating.	Cost Protection.	Cost Street Boxes.	Labor Laying.	Total.
Drawn in: 1-4" stoneware pipe	£625	£100	£65	£30	£820
Drawn in: 3-2" stoneware pipe	625	176	65	30	896
Solid laid (bitumen) wooden trough	625	185	10	15	835
Solid laid (bitumen) asphalt trough	625	195	10	15	845

into the troughs. The surface must not be allowed to set too rapidly or the imprisoned steam will form blow holes and a spongy, non-damp proof casting will result.

A substitute for *mineral pitch*, much inferior in most respects, is *coal tar pitch*; the latter is occasionally used for cable trough filling, but the flexibility and adhesiveness possessed naturally by asphalt have in the case of its substitute to be imparted as far as possible by the thor-

Taking into account its manifold advantages in service the "solid" bitumen-laid line is remarkably cheap. The cheapest system of laying is to employ an armoured cable laid direct in the ground and protected by a creosoted plank, laid a small distance above it. The cost of such a system complete would be about £775 per mile (in this case), the cost of armouring (£90 per mile) largely discounting the economies effected on the remaining items.

WIRELESS COMMUNICATION FROM AIR SHIPS

By A. Frederick Collins

WHILE the desirability of equipping air craft with wireless apparatus is apparent to anyone who has given a thought to the subject, the absolute necessity of such installations, especially when extended flights are to be made, was vividly realized during the recent attempt to cross the Atlantic by Wellman and his crew in the air ship *America*.

The rescue of these intrepid men was the net result of the excellent foresight of those in charge of the exploit and a little luck, and the elements may be summarized in the statement that it consisted of (1) a dirigible balloon for the air craft, (2) a sea route for the proposed attempt, and (3) a wireless equipment for sending forth signals when help was needed.

By employing a dirigible balloon the aviators were enabled to remain in the air for an indefinite time, as well as to carry a considerable load, of which the wireless apparatus was a part; moreover, by flying seaward they were able to keep in touch with passing ships, wherever they might be, and this by virtue of the excellent ground, or earth connection, an essential for the wireless transmission of messages, afforded in this case by the steel drag rope trailing in the sea.

An aeroplanist has many adverse features to contend with, as compared with the pilot of a dirigible, in considering the favourable application of wireless apparatus on his craft. For instance, a drag rope, making contact with the sea, is not a practical scheme, while the weight of the apparatus itself is an additional handi-

cap. As affairs now stand, the aviator has little time to manipulate a wireless set, as every moment must be devoted to operating, steering and balancing his craft.

The immediately practical utilization of both types of flying machines seems logically to be for the purpose of scouting in war manœuvres; but, without the means of communicating with the general of the division or the commander of the fleet, the possibilities of the flying machine as a tactical and strategical instrument would be seriously impaired, while if the apparatus were disabled by a shot fired from one of the new guns devised for the especial purpose before any information had been transmitted the value of the aerial observations would be entirely lost.

The dirigible balloon *America* has the distinction of being the first air craft to make a practical test of wireless telegraphy under actual flying conditions, and, as both the dirigible and the wireless equipment possessed many novel features, the combination was especially interesting.

The total length of the dirigible was 228 feet, with a maximum diameter of 52 feet and a capacity of 345,000 cubic feet of hydrogen gas. A framework, called a car, constructed entirely of steel tubing, was suspended from the balloon by means of hemp rope and steel wires. A flooring was laid on the bottom of the car, and on this were placed the engines, of which there were three—two, of 80 horse-power each, to drive the propellers, and one, of 20 horse-power, for the generation of electric current used for lighting the



FIG. 1.—THE "AMERICA" IN FULL FLIGHT

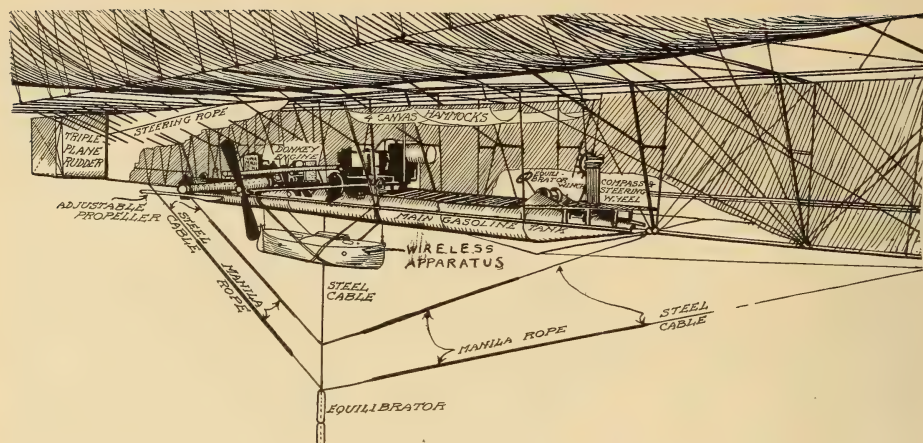


FIG. 2.—GENERAL ARRANGEMENT OF CAR OF "AMERICA"

car, charging the storage batteries for the wireless set, etc., as well as the steering wheel, electric winch and other machinery. Attached to the bottom of the car was a large gasoline tank, 2 feet in diameter and 150 feet long.

Suspended under this tank, but held securely in place by guy ropes attached to the car, was the lifeboat, and stored snugly away in a forward compartment of this boat was the wireless apparatus. From the latter a connection was made with the car, which served as the aerial of the system. The *ground* was formed by connecting the instruments with a steel drag rope, which was supported by and insulated from the car by four guys, each made up of steel cables and manila rope, the latter being boiled in oil to increase its insulating properties. This drag rope, which has become famous as the "equilibrator," is shown in Fig. 1, and, while Mr. Wellman and his associates have considered it as the chief cause of their failure to cross the ocean, it was undoubtedly instrumental in saving their lives, inasmuch as it formed the *ground* of their wireless apparatus.

The purpose of a drag rope in ballooning is well known, such a device having been used for many years for the object of equalizing

automatically the variations in the lifting power of the gas bag, due to the influence of temperature changes, etc., upon the hydrogen gas. In the case of the Wellman balloon a number of steel tanks, each containing about a barrel of gasoline, were strung upon the drag rope, and these, by means of a winch, could be hoisted into the car should the necessity arise for more gasoline than was contained in the main tank. The drag rope thus filled a threefold purpose, serving (1) as an equilibrator, (2) as a storage system for fuel, and (3) as a sending and receiving antenna for wireless messages, this latter proving to be more useful than either of the others in the actual event.

In selecting a suitable wireless apparatus for the *America* the questions of lightness, completeness and freedom from fire hazards were considered in the design as well as in the operation; and the general arrangement of the equipment will be seen from the following description and sketches:

A wireless transmitting station of the simplest type is represented in Fig. 3 and the receiving set in Fig. 4. The sending arrangement comprises: *A*, a battery; *B*, a telegraphic key, and *C*, an induction coil. When the key is pressed down, the primary cir-

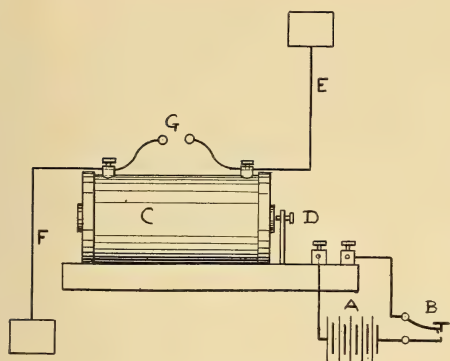


FIG. 3.—A WIRELESS TRANSMITTER

cuit is closed and the current from the battery energizes the primary of the induction coil, when the interrupter *D* automatically makes and breaks the circuit several hundred times a minute. This sets up in the secondary winding of the coil currents of high potential, which alternate in direction every time the interrupter makes and breaks the circuit. These high-potential but low-fre-

quency alternating currents charge the aerial wire *E* and the ground wire *F* negatively and positively until the potential difference is sufficiently great to break down the insulating film of air between the spark balls at *G*. The static charges, being released, rush together and produce a current of both high potential and high frequency, termed an *oscillating* current, and this surges through the aerial and ground wires at a speed of hundreds of thousands of times a second while it lasts. The current, however, is of only momentary duration, for, as it surges to and fro in the aerial wire system, a large portion of its energy is converted into electro-magnetic waves, which are propagated in every direction at right angles to the aerial wire.

The receptor, for catching and indicating these waves, comprises, in its simplest form, an aerial and a ground wire, *A* and *B*, respectively, an electric wave detector *C* and a telephone receiver *D*, as shown in

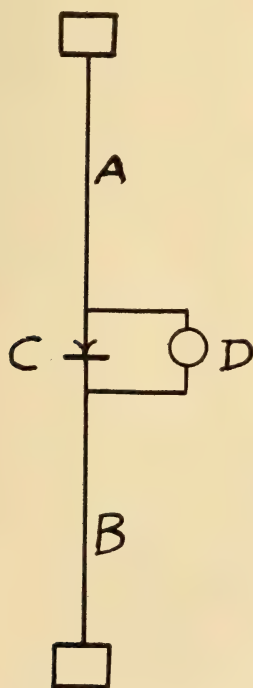


FIG. 4.—SCHEME OF WIRELESS RECEIVER

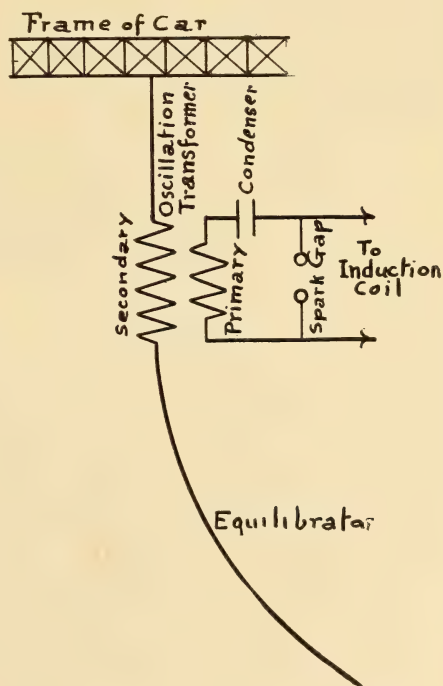


FIG. 5.—THE TRANSMITTER OF THE "AMERICA"

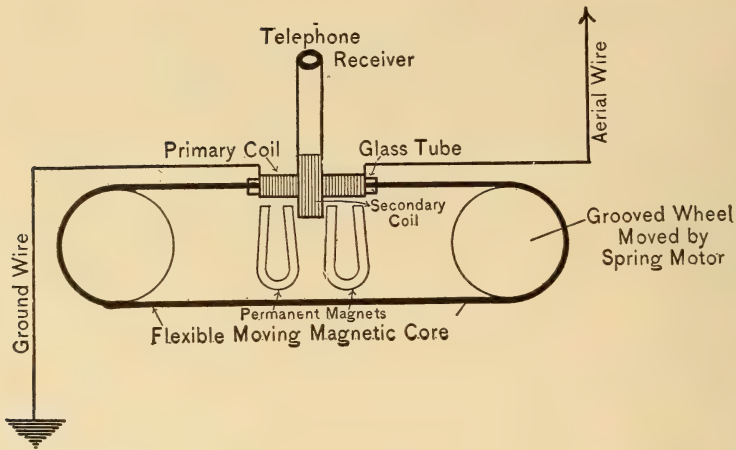


FIG. 6.—MARCONI MAGNETIC DETECTOR

Fig. 4. One of the best as well as the simplest detectors is made by merely joining a contact between a steel or brass needle point and a piece of silicon, the needle being connected to the lower end of the aerial wire, while the silicon is connected to the free end of the ground wire. The telephone receiver is shunted around the detector.

Now when the electric waves emitted by the aerial of the sending apparatus impinge upon the aerial of the receiving instrument the energy

is re-converted into oscillations of high frequency, and these, surging up and down the aerial wire system, pass through the contact formed by the needle point and the silicon, which acts as a rectifier and changes the oscillating current into a direct current; the latter is capable of energizing the magnets of the telephone receiver, and its diaphragm responds accordingly, thus producing clicks which represent the dots and dashes of the telegraphic code.

The Marconi apparatus installed in the *America* represented an improved device, as a comparison of the diagrams Figs. 5 and 6 with Figs. 3 and 4 will show. Since the ground end of the wireless apparatus was connected to the equilibrator, which formed a part of the oscillating system, and as the cable of the former continually varied in length with the variations in the position of the balloon, the period of oscillation varied accordingly. To mitigate, as far as possible, the untoward effect of this changing wave length, an *oscillation transformer* was used; and this, in the terms of the wireless engineer, was *loosely coupled*, a term which will presently be defined, and which is indicated in Fig. 7.

In this apparatus, instead of connecting the aerial and ground wires directly to the spark balls, two or

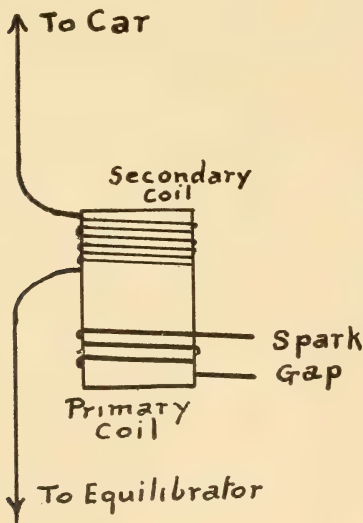


FIG. 7.—A LOOSE-COUPLED TRANSFORMER



FIG. 8.—WIRELESS OPERATOR C. D. NESBIT, R. M. S. P. "TRENT," RECEIVING COMMUNICATION FROM THE "AMERICA"

three turns of heavy wire, forming the primary of the oscillation transformer, were connected, together with a condenser, to the balls, thus forming a closed oscillation circuit. The secondary of this transformer consisted of forty or fifty turns of finer insulated wire, and the ends of this coil were connected to the aerial and ground wires, respectively, this

forming the *open* oscillation circuit, or aerial wire system. When the primary and secondary coils of the oscillation transformer are placed closely together, the open and closed circuits are said to be *close coupled*, and when the coils are widely separated the circuits are said to be *loose coupled*. It is the latter kind of coupling that gives the best results

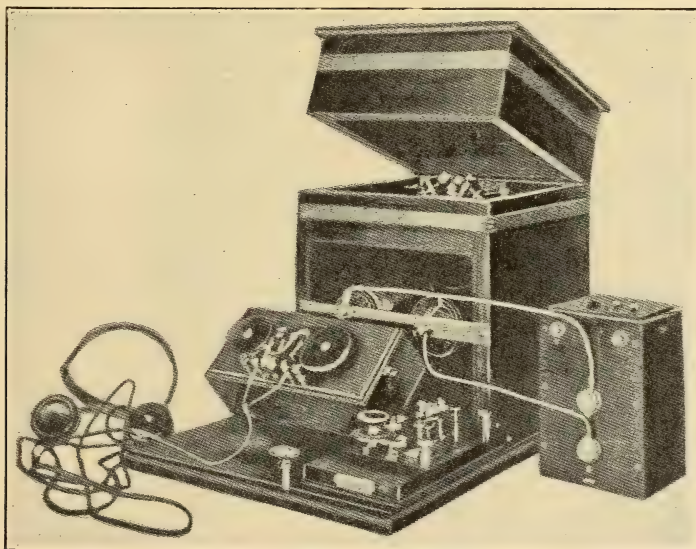
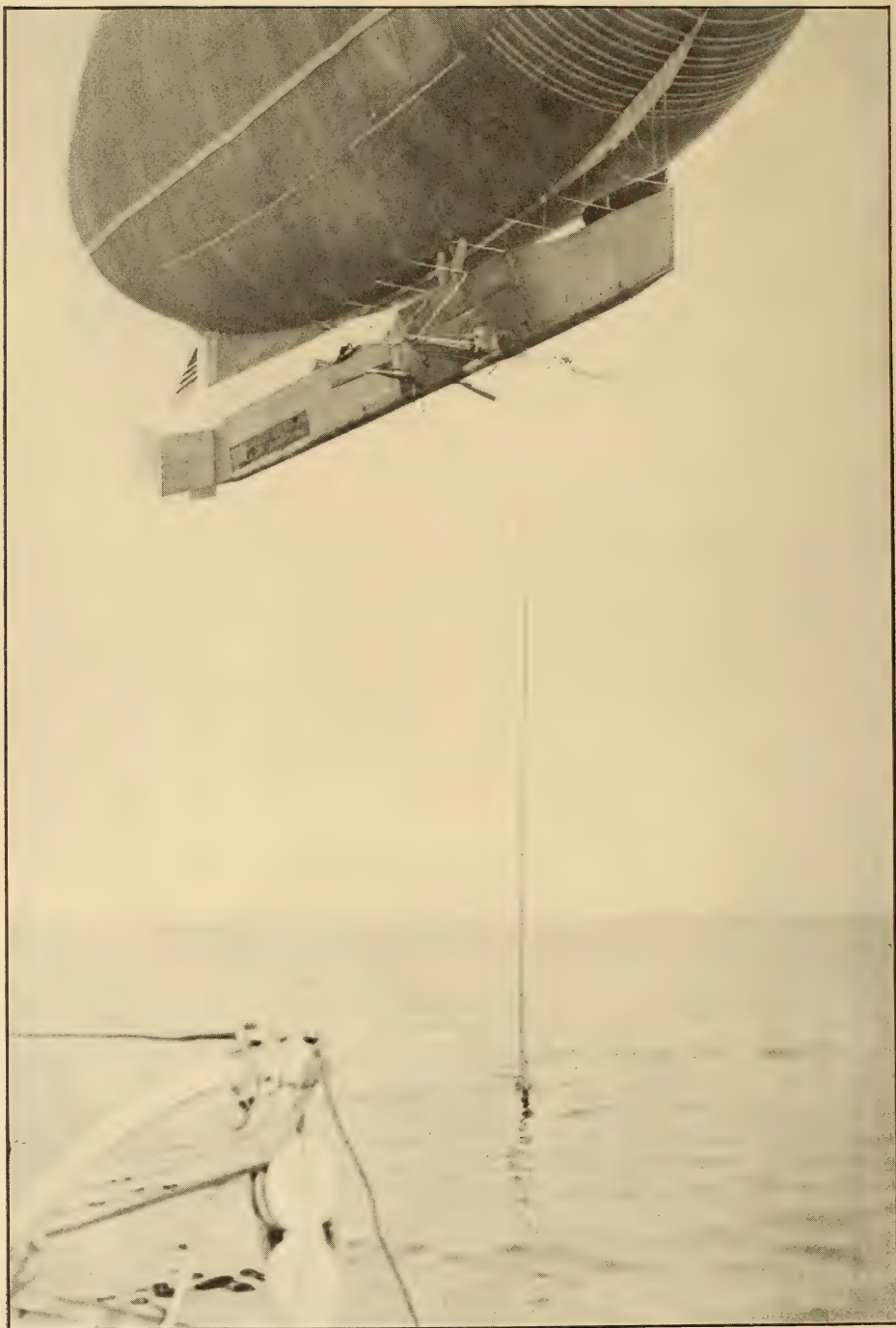


FIG. 9.—THE WIRELESS EQUIPMENT OF THE AMERICA



THE DIRIGIBLE "AMERICA" AFTER RELEASE BY THE CREW

when there is a difference in the received wave lengths.

In this type of transmitter, when the spark takes place the oscillating currents surge in the closed circuit with great persistency, for, in closed circuits, the energy is not damped out to any extent in the form of electric waves. But as the currents traverse the primary coil of the transformer the energy is transferred into the secondary coil, where the potential is increased in accordance with the well-known law of transformation, and the oscillations surging in the aerial wire system damp out the energy in the form of electric waves, which are radiated out into space.

The receptor employed on the *America* is shown in Fig. 6, and consisted of a Marconi magnetic detector, the aerial wire system, and a head telephone receiver. It will be remembered that the aerial and ground wires are connected to the opposite terminals of the primary of a small oscillation transformer. The ends of the secondary coil are connected to the telephone receiver. The coils of the transformer are wound over a bit of glass tubing, and through it is a band of soft iron wires, running over grooved pulleys, caused to move slowly by means of a spring motor. This iron band is magnetized by two permanent steel magnets, and when oscillations traverse the primary coil they change the magnetic intensity of the moving band of wire, and this sets up currents in the secondary coil and so operate the telephone receiver.

In wireless telegraph stations it is usual to have as high an aerial as may be expedient, and, as the station rests on the ground, the wire making the earth connection is quite short. If the station is on shipboard, the steel hull of the vessel is used as the ground. In the case of the *America* the conditions were practically reversed, the aerial being very short, comprising the framework of the car, and the ground exceedingly

long, since the equilibrator was used for this purpose. It should be considered as an inverted aerial; but as the capacity of the framework was fairly large, and a good ground insured by the cable drag,* the results were all that could be expected, considering the small initial energy used.

The actual power employed was approximately 250 watts, a standard Marconi 10-inch induction coil being used to transform the low-voltage current into high potential oscillations. With this small amount of power the danger from sparking was negligible, while actual tests with this set demonstrated that distances of fifty miles and upwards could be covered.

The difficulty of installing wireless sets on aeroplanes, as previously pointed out, is greater than on dirigibles, since the equilibrator is not only unnecessary, but would prevent the craft from flying. It would be possible to have a thin aluminum wire a few hundred feet in length trailing after the machine, but this would not provide a good ground. In view of recent experiments, made by Count Alessandro Artom, in projecting circularly polarized electric waves in a given direction, it would seem that the ground might be eliminated.

That the wireless telegraph can be applied to aeroplanes there is no doubt, though admittedly the obstacles are great; but when it is needed badly enough some genius will arise, equal to the occasion. The ideal method of communication between air craft and air craft and the earth is obviously wireless telephony; but, owing to the comparatively high initial voltages and the necessity at the present time of using direct currents, the difficulties are even greater than with wireless telegraphy.

The whole scheme is, figuratively, in the air—we wish it were there literally; but it must be remembered that the wireless man is yet in his swaddling clothes and the air man has just been born.

SOME TIME-SAVING ARRANGEMENTS

By W. Burns

TO secure cheap and accurately manufactured work at the present time, it is essential that as little hand labour as possible should be expended on the work after it leaves the machines, and a minimum of machine work be necessary.

The designer takes this into account and plans the machine or structure so that it will fulfil its purpose efficiently and be assembled with a minimum of fitting, the work being finished during the machining operations.

An instance of this may be noticed in the case of the swiveling type of bearing, which has been in use for many years in shafting, electric motors and other machines, and is now being used for some very large bearings.

This form of bearing requires practically no fitting; the bush is turned to a limit gauge in the bore, and for the ball-bearing portion on the outside. There is not as much machine work as in the case of the parallel brass bush, as the bracket or pedestal requires to be bored out to size, faced up, and the bush fitted in.

With the swivel type of bush there is only the boring out of the bracket to fit the ball-shaped part of the bush; a very easy matter where the bushes are made in standard sizes; roughing out the metal with a tool, then finishing to size with a ball-shaped reamer.

To facilitate machining, and to give the ball-shaped portions a better grip, the center strip of the bush and the bearing is coved out (Fig. 1). The bush is thus supported on a strip at each side of the pedestal. This not only allows the bush to swivel to suit the shape, it also forms a good shoulder, and the bush is capable of withstanding a heavy end load. This is not the

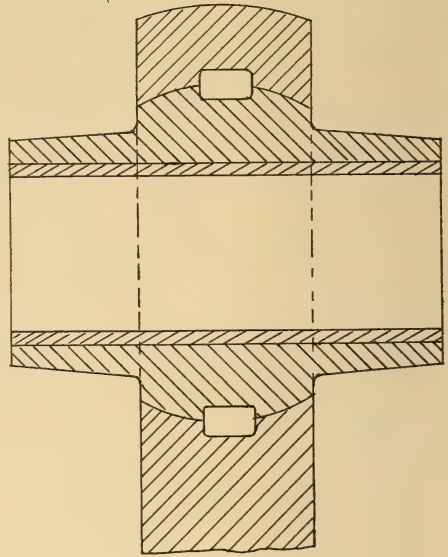


FIG. 1.—SWIVEL BEARING

case with all swivel bearings, some of them depending on a narrow center strip slightly rounded to support the axial load, while a pin inserted in this strip is all that is used for any end thrust. With the other style of bearing, when the cap is screwed up, the bush is practically locked solid in both directions; it also possesses the advantage that no fitting work is required when erecting, the oil grooves and holes being machined in the machine shop.

If this type of bearing is used on a machine in which several parallel shafts gear with each other, for instance, in the crab of an overhead traveling crane—the brackets for each shaft may be made separately—then in assembling, if they are mounted on their respective shafts, and these spaced the correct distance apart, by means of forked distance pieces

(Fig. 2) passing over the shafts, the entire gearing may be easily and accurately built up without any preliminary setting or marking off. This of course is in the building of a standard machine and where numbers of the same size are required.

If parallel turned bolts are used (and they are very common) the pedestals or brackets may be clamped in position and the holes bored through the soleplate or frame; the bolts fitted in; and the machine is practically erected.

With this method of construction, if any part should be broken or worn out it can be easily replaced without dismantling or making other new parts which might be connected with it, if the journals were all in one casting. Then if the keyways in the

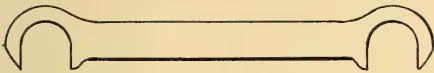


FIG. 2.—FORKED DISTANCE PIECE

shafts are milled to suitable gauges, and the keyseats in the hubs slotted or broached out to gauges also, and standard keys used, very little fitting will be necessary.

It is hardly necessary to instance the case of a piece of work machined in a jig, and requiring no fitting beyond the assembling of other parts on to or into this particular piece.

Again, preference is often given to a design which allows all surfaces to be machined at one setting of the work or in one machine, and in which it is practicable to have cutting tools at work on each surface at the same instant.

In this connection a minor point is in the designing of edges of work, so that when the various parts are assembled no dressing off by metal will be required to give the work a finished appearance. One method of accomplishing this end is to make the one surface larger than the other and round off the larger surface at the edges to a fairly large radius (the size and class of work being, of

course, taken into account), the idea being to so proportion the larger surface and rounded edge, that, within a given variation from position, or size, the discrepancy will not require any connection by chipping or machining. The outer edge of the small surface may be slightly rounded to keep it in harmony with the other (Fig. 3).

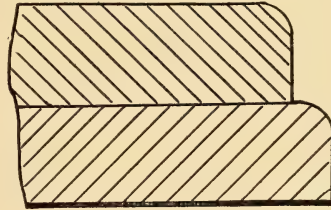


FIG. 3.—FINISHING EDGES

When a distance piece or fitting strip is made use of, as in the case of, say, the crank pin bush on a large connecting rod, the edges of the bush and distance piece may be rounded in the same manner (Fig. 4).

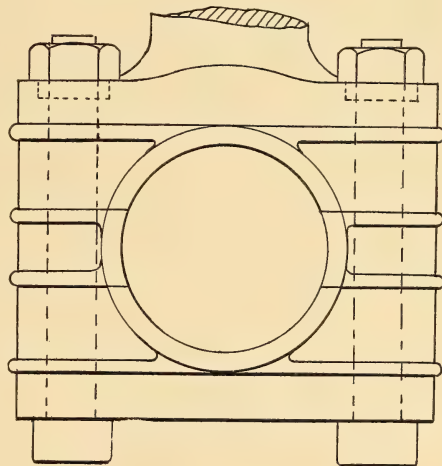


FIG. 4.—CONNECTING-ROD END

The bearings for a countershaft on which very little machine work is required are shown in Fig. 5 and Fig. 6. In Fig. 6 the only machine work required is boring out the hole for the shaft and facing up the ends for the collars, the bush being supported in the hanger by means of a bolt passing

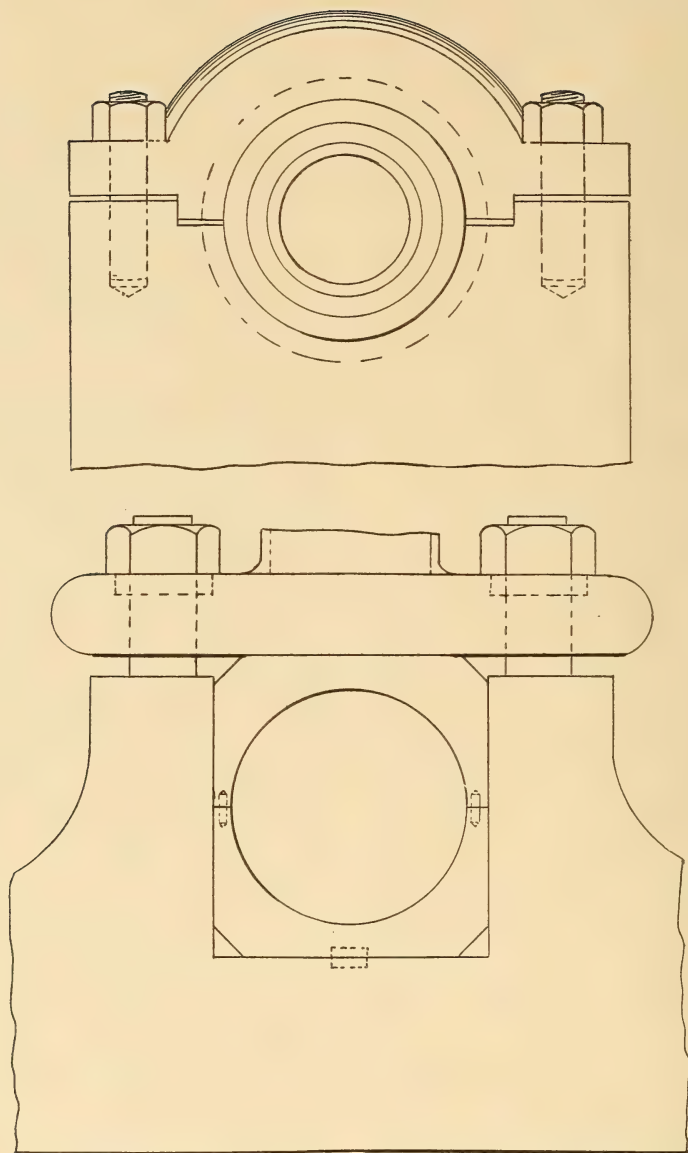


FIG. 7.—TWO BEARINGS FOR SOLE PLATES

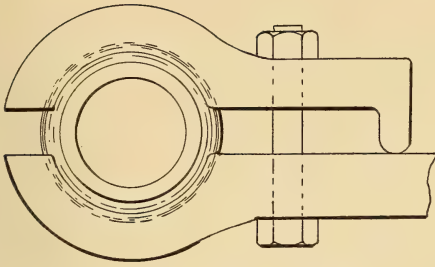


FIG. 5.—COUNTERSHAFT BEARING

through the coved hole on top. This makes the bush self-aligning in one direction, and provision is made by oblong holes in the hanger for setting in the other direction when erecting.

In Fig. 5 is shown another design of the self-aligning bracket. The machine work is the same as in Fig. 6, viz.: boring and facing the hole for the shaft: the rounded part on the sleeve and the recess for same in bracket and cover being left as cast, the bolt holes are also coved out.

If the moulding and casting have been carefully done there will be no trouble in assembling the bearing.

With these bearings it is impracticable to use a shaft with solid collars, the practice being to use a short length of rolled shafting and use loose collars held in place by set pins. Sometimes a flat filed on the shaft serves to key on the driving and cone pulleys, though occasionally keys and keyseats are dispensed with and one or more case-hardened set-screws used to fasten both pulleys to the shaft.

Some of the cheaper styles of bearings for shafting are the ordinary type of pedestal fitted with round brass bushes and cast iron cap, the bearing,

bushes and cap being assembled direct from the castings, all bolt-holes and recesses being coned out, the only machine work being the boring out and facing up the brass bush.

A method that is sometimes adopted to hold the bushes in place in a sole-plate where there are a number of bearings, and there is no end thrust, is to fit a dowel pin in the bottom half of the bush (Fig. 7) and two smaller sized pins at the center of the bushes, there usually being two pins on each side. This saves the machine and fitting work on the flanges, which would otherwise be required; it also saves the machine work on the edges of the gaps for the bushes in the sole-plate. If the bush is cast without sharp corners, as shown, time will be saved in machining the gaps, as they will not require to be cut out to a sharp corner; if they clear the bush at the corners the metal left on will help to strengthen the casting at a weak point.

Another application of the rounded edge is that for the bearing cap where the ends are rounded off, the only machining being the planing or milling of the side next the bush and the boring of the bolt holes.

Where there are a number of bushes of the same size and fairly long compared with the diameter, they may be broached out instead of boring out in the lathe. If the broach is kept in nice order and the brass castings are fairly true, the broach may be put through on a press, and a good, accurate job can be relied on. The outside and ends are finished by placing the bush in a standard mandrel and finishing in the lathe.

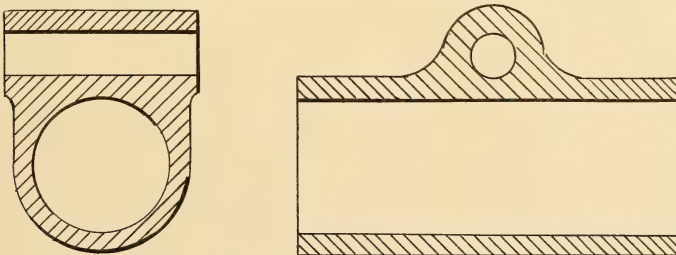


FIG. 6.—ANOTHER TYPE OF SIMPLEX BEARING

MINING ACCIDENTS

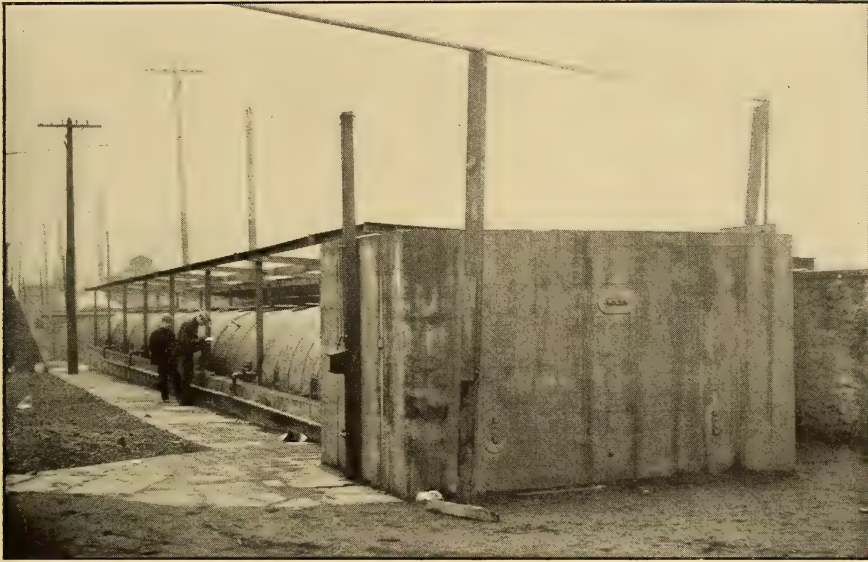
By Day Allen Willey

WHEN the mining of coal is considered in connection with other great industries of America, one of the most important features—one of vital importance—is the element of safety. How the work can be prosecuted with a minimum of danger has long been the study of the mining engineer. It is to the credit of the mining companies to say that in many instances they have provided known safeguards regardless of expense, and have not neglected precautions against fire and explosion, but the great and rapid development of the industry has in its progress far outstripped the development of apparatus for safety, means for averting the accumulation of gases and appliances for protecting the miners and other underground workers whose employment is necessary.

In discussing this subject it is to be remembered that nearly 800,000 men and boys are in the coal mines, the greater majority in the bituminous workings. The records show that the number of those killed or injured in a single year have been as many as 10,000, or nearly one-seventieth of the total. But a single accident may result in hundreds of fatalities as illustrated by the casualties that have recently occurred in West Virginia and Illinois; in some instances in mines supposed to be properly ventilated and naturally generating but a small percentage of gases. A comparison between the United States and other coal-producing countries as to the annual mortality from such disasters shows that the average American death rate annually for 1907 and 1908 alone was

four and one-fifth men to each thousand employed. Great Britain has nearly a million colliery workers, Germany being third, with over 612,000, nearly as many as the United States, yet the British death rate is less than one-third of the mortality in this country, and Germany about five-eighths.

This accounts for the fact that the investigation of the cause and prevention of mine accident has aroused more attention among colliery experts than ever before. This interest has already been of much value, as it is arousing mine owners to the necessity of providing every precaution that can possibly be provided. The impression prevails among engineers who have visited the mines in the European fields that the system for safety in the various operations is on a higher standard in most of these collieries than in America, but it should be remembered that in Europe the industry is old, while here it is new, and coal operators have not had the experience of the British, Germans and Belgians. On the other hand, some of their pits have been mined for centuries. The bulk of the material is elevated by shafts, some of them reaching over 500 feet below the surface. Consequently far more ventilation must be provided and methods to remove the gases accumulating at this depth to keep them from accumulating to the danger point. We must admit that the statistics of the death rate show more favourable in Europe than in America, in spite of the greater opportunities for fire and explosion on account of the depth of these collieries.



VIEW OF GALLERY, SHOWING THE HEAD OF CONCRETE, ALSO VENTS AND PIPING FOR ADMITTING GASES
FOR TESTING PURPOSES

As the American industry has developed, more and more dangers have come to the knowledge of the engineers. As shafting has taken the place of tunnels to reach lower veins, it has been found that the so-called "fire-damp" accumulates more rapidly at a lower level. The inflammability of coal dust and its ignition even with a minimum amount of heat have only been realized in recent years. The heaviness or lightness of the atmosphere outside is another condition that must be considered in mine ventilation, while the question of explosives employed in loosening coal formations is another element of vital importance. Many a mine fire has spread from gallery to gallery by the way in which the shoring and other false work were planned, and at last the point has been raised if some substitute for wood should not be employed, especially in workings containing a high percentage of gaseous vapor. These are some of the reasons why it is gratifying to know that the Government, through the United States Geological Survey, has begun an investigation so comprehensive and

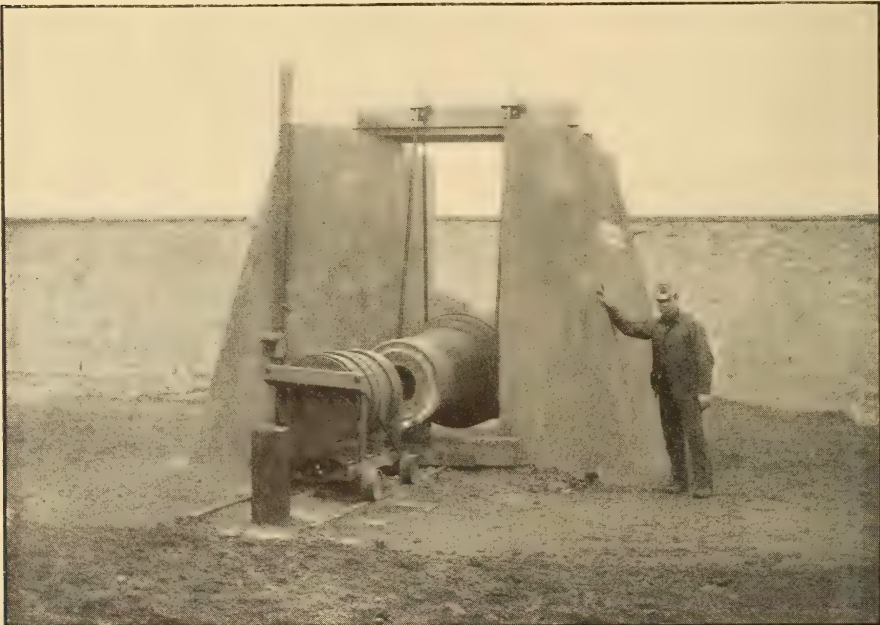
varied that already the results obtained through examinations and tests have been of the greatest value towards solving an industrial problem of the greatest character. The principal centre of experiments to determine the cause and prevention of mining accidents is located in the city of Pittsburg, where it has the advantage of being in one of the great centres of coal production. It has been in charge of Mr. Clarence Hall, the chief of the Bureau of Explosives of the Geological Survey. A description of the principal features of the station will give an idea of the diversity of investigations.

The tests of various powders and other explosives used in blasting coal are being made in a boiler-plate gallery, previously filled with gas or coal dust, or a mixture of them. The gallery is 100 feet long and 6 feet in diameter. Safety valves are located along the top, and are left unfastened in such a manner that whenever there is an explosion, the valves are forced open. A series of portholes on the side of the cylinder, fitted with heavy glass, enables witnesses to view the results from a

parallel observation house sixty feet distant. Explosive mixtures of fire-damp and air or coal dust and air, or coal dust and fire-damp are pumped into the cylinder, and the explosive which is to be tested is shot into the mixture from a cannon, so that the flame penetrates into its midst. Natural gas is, however, substituted for fire-damp, because it corresponds very closely to this deadly gas.

The explosion gallery is arranged so that gas can be piped to any one of the fifteen sections. The safety valves or doors would not be needed in that length of tube for coal dust, for coal dust explosion takes time to generate force, but in an explosion of a fire-damp, which is very quick acting, it is necessary to relieve the pressure. In a concrete block at the end is set the cannon, in which explosives for testing are placed. The cannon has a drill-hole, which is 20 inches deep and $2\frac{1}{2}$ inches in diameter, and causes a blow-out shot such as may take place at the face of a working place in a mine.

In the experiment, coal dust is placed on shelves along the side of the gallery and on a wood horse bracket, which is underneath the line of the hole. This is similar to a condition that frequently occurs in a mine where there is a pile of machine cuttings or coal from previous shots, and another is fired over or into it. Under such conditions in the gallery, bituminous dust invariably explodes. The appearance at the start of a dust explosion in the gallery is shown by a photograph taken instantaneously. Such an explosion rapidly runs the length of the gallery. The violence increases as it progresses. The flame and smoke will shoot out at the end of the gallery 40 feet, hit the massive concrete back-stop and leap into the air. When there is no ignition there is no black cloud, merely a white vapor from the explosion in the first valves and light gray clouds beyond. The mortar, or cannon, is hung on a pendulum. It does not give any positive figure as to foot-pounds of pressure generated, but it does give,



BALLISTIC PENDULUM GUN FOR TESTING EXPLOSIVE FORCE OF MINE GASES



NEAR VIEW OF THE EXPLOSION, SHOWING THE IMMENSE VOLUME OF GAS AND SMOKE AND THE VELOCITY OF ITS MOVEMENT FROM THE GALLERY

by the relative swing, the relative strength, an illustration so that one can compare a high explosive with a low one. This arrangement, or a similar one, was designed by Captain Desborough, of the English Mines Explosive Department. In the flame-testing apparatus the explosive is placed in a vertical cannon shooting upward. Inside the building there is a photographic machine with a rapidly revolving drum, carrying a sensitized film, and as this revolves it photographs through a slot a series of pictures of the flame. That gives the length of the flame of the explosive, and also, by the number of these successive pictures, the duration of the flame, because the drum revolves at a known speed.

For testing safety lamps in currents of different velocities and of various mixtures of gas and air, the lamps are placed in any one of the openings and the glass door is then fastened. There are hinged flaps

above to relieve the pressure of an explosion. There are also certain indicator arrangements by which can be determined the speed and mixture in which the lamp is to be tested. The various positions of the openings into which the lamp is inserted allow testing in horizontal, 45 degrees ascending and descending, and in vertical ascending and descending currents. The Bickel machine is installed for testing the pressure generated by an explosive. Two different sizes are employed, so that there may be a relation obtained between the weight of the explosives used and the cooling surface of the apparatus, and in that way certain variables may be eliminated in the calculations. The explosive is placed in the chamber and exploded by an electric spark. There is a plunger attached to a lever operating a marker, which traces a line on a drum, revolving at known speed, and thus indicator diagrams are made

on a card which shows the variable pressures. The latter rapidly raise to a high point, gradually descending as the gases cool. A pressure gauge is attached to obtain the pressure of the cooled gases. The usual charge of explosive is 50 grams. Figured into pounds, 1 pound of explosive will ordinarily make about 5 or 6 cubic feet of the fixed gas. The gases are drawn off and analyzed. A calorimeter bomb containing the

stretch. The life-sustaining gas is in the form of compressed oxygen, stored in a cylinder, which is carried by the rescuer on his back, the oxygen being connected with the operator's mouth by a flexible, rubber-lined metallic tube. The rescuer's exhalations are passed through small lumps of potassium hydroxide, which absorbs the carbonic acid gas, after which the nitrogen, together with more oxygen from the cylinders, is



EFFECT OF AN EXPLOSION IN TESTING GALLERY AT PITTSBURG. THE SMOKE AND GAS IS ISSUING THROUGH VENTS AFTER THE IGNITION OF BLACK-DAMP BY CONCUSSION

explosive is placed in a water bath of known temperature and is moved up and down until the bomb and water are of the same temperature. This is to ascertain the total heat generated by the explosion.

The feature of the station of much human interest is the mine rescue work by use of the oxygen helmet. Fitted with these helmets, a man may work with comparative comfort and efficiency and perfect safety in the fumes of the most deadly gas for two hours at a

again available for the operator. For the training of men in the use of this rescue appliance and in other details of life-saving, a part of the Pittsburgh station has been planned as a model coal mine. This is a large glass-encased air-tight room which contains difficult passages, such as exist in coal mines. There are also various obstructions similar to those found in a mine after it has been wrecked by an explosion. Dummies are also provided, weighing from 150 to 200 pounds each, rep-



RESCUE CORPS READY FOR SERVICE, SHOWING HOW THEY ARE PROTECTED FROM THE GASES

resenting asphyxiated miners. This apartment is filled with sulphur gas and corps of men wearing the helmets remain in this chamber for two hours, removing obstructions, picking up the "mummies," giving them emergency treatment, placing them on stretchers and carrying them away. It might be added that a machine which records the amount of work a man may be expected to do while in the gas-charged chamber is included in the apparatus at the station.

Pittsburg and other stations which have been established have engineering staffs to study the waste of coal in mining—one of the important problems before the Geological Survey—and for investigating conditions in mines which may be conducive to disasters from explosions or roof falls. The other stations are equipped with air-tight rooms where gas can be generated. Coal mining companies are invited to send to them

picked men who may be trained by the Government experts. It is not the purpose of the Government to engage in general rescue work, but rather to educate by means of this apparatus until the mining companies have thoroughly trained rescue crews at their mines.

The importance and value of the tests made in the quality and effect of explosives utilized in mining have proven the work at Pittsburg to be a necessity, as shown by the opinions of experts who have made a study of the methods. Chief engineer Watteyne, of the administration of the mines of Belgium, may be quoted in this respect: "The use of explosives is, and especially was, the principal cause of danger of explosion in the Belgian mines. It is this cause which previous to 1890, before the generalization of safety explosives and before the use of explosives of every description had been reduced by various means to a mini-

mum, brought about deadly catastrophes. Within the decennial period (1880-1889) the number of victims of ignitions caused by the use of explosives reached 90 per cent. of the total number of victims of explosions in mines.

It may be asked: What is the reason for such a preponderance, considering that the number of lights introduced into the mine by the lighting apparatus is far greater than the number of shots? It would be too long to examine here in detail the causes of the greatest danger of explosives, but the principal ones may be mentioned in a few words. On one hand the safety lamp, though still imperfect, has acquired a fair degree of safety; on the other hand the flame of a lamp, even when uncovered, cannot ignite a fire-damp mixture unless its proportion of fire-damp be very high, say $6\frac{1}{2}$ to 7 per cent., a proportion which the aspect of the flame betrays in a very

apparent manner a long time before; nor can it ignite a mixture of dust. The case is different with the violent flames caused by the explosion of charges, for these are not only liable by the shock they produce in the atmosphere of the workings, to call forth to the dangerous point an unexpected rush of fire-damp, but they can ignite the clouds of dust, which this very commotion has raised, and in this way can bring about terrible catastrophes, while in consequence of the apparent absence of the fire-damp one may think himself nearly safe.

"The endeavors made after 1887, in consequence of disastrous explosions, to reduce the danger of explosives have brought about a very sensible reduction of the number of the victims of blasting. Thus, within the following decennial period, from 1890 to 1899, in spite of the accident of Anderlues, which, in 1892, made 160 victims, the total number of men killed



MODEL OF MINE, SHOWING METHOD OF REMOVING VICTIMS OF AN EXPLOSION AND APPARATUS FOR REVIVING THEM

by mining explosions in Belgium has been reduced to 258, from the previous figure of 455, the proportions of victims of ignition by the use of explosives having fallen to 23 per cent."

Other features of European mine protection include the watering of the sides and roof of coal-mine passages, which has been found to be of material benefit in preventing local ignitions of coal dust from becoming general. The watering prevents the coal dust from being stirred up by a small explosion, and the reduction in the explosive properties of the wet coal dust has a general effect of preventing an explosion from traveling into other workings. As dust explosions gain in destructive effect the farther they travel, it is believed that the thorough watering of zones greatly reduces the destructive effect of such explosions. The watering is effected by means of sprinkling or spraying devices of various kinds. Specially constructed nozzles are in use, particularly in Germany, which produce a fine spray or mist by means of water under pressure, so that the air is thoroughly moistened.

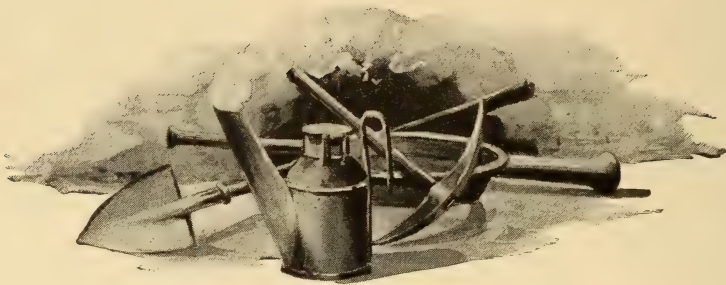
The mining regulations of France, Germany and Belgium require that mines shall be supplied with means for administering to the comfort of injured workmen, and that proper appliances shall be provided for first aid. Rescue devices equipped with small tanks of compressed air or compressed oxygen, or with some chemical appliance for generating a supply of oxygen, so as to enable a person to enter mine workings in which an irrespirable atmosphere is present, are required in some countries. By the aid of such apparatus, rescue parties may enter the mine workings immediately after a fire-damp disaster and save injured miners, who would otherwise soon fall victims to the poisonous atmosphere surrounding them. Mine fires started by the ignition of fire-damp may be brought under control much more easily when immediate efforts are made to combat them by men equipped with rescue devices.

Regarding the agitation in this country, it should be added that the work of the Geological Survey has not been limited to the centres established, although here thousands associated with the coal industry, from miner to superintendent, have been instructed in the preventive methods, as well as the rescue of victims and prompt aid to the injured. The evidence of public interest is shown by the organization of the Red Cross Society of a special bureau of nurses and aids, equipped with safety appliances for rescuing the miner. It may be needless to say that this movement has resulted in a bill introduced in Congress to create a Bureau of Mines. Its purpose as outlined is to provide scientific inquiries and investigations for the benefit of the mining industry, such investigations as will aid in making mining in the United States less wasteful of life and resources. These investigations will be useful to the State in the enactment of better and more uniform laws and regulations; useful to the State inspectors, operators and miners by supplying them with reliable data concerning explosives, gas, dust, mine fires and other factors entering into the problem of mine safety; useful in solving the problems of the more efficient treatment and use of metallic mineral products; useful to the general public as supplying impartial data as the basis of intelligent public opinion. This bureau will make inquiry and investigations to discover the various causes of each type of mine accidents and the best preventive measures; to aid in developing a uniform code of signals for use in mine operations and a system of warning signals, indicating when men should leave one or all parts of the mine, and the route to be taken so as to avoid the poisonous gases; to develop more efficient and cheaper methods of mine rescue work, and to develop more effective methods of preventing or fighting mine fires.

This national bureau of mines, through its investigations and educational work, will contribute largely to-

wards bringing about this desired result; greater safety and efficiency in American mining and less waste by the people and by the Federal Government in its own use of fuel and other mineral products. The benefits to the Federal Government arising from this last-mentioned phase of the work may be reasonably assumed as sufficient to cover the entire cost of maintaining the bureau, while to the mining industry and to the people in all the States, whether producers or con-

sumers of mineral products, the benefits arising from the work will be large and continuous. These benefits will be increasingly important as American resources become scarcer and less equal to the larger and larger demands of a growing nation and its expanding commerce. These purposes are not adequately provided for under any existing Government bureau, although every country of Europe containing collieries has such an organization.



THE PORT OF MANZANILLO

By Harry H. Dunn

IN order to furnish a port capable of handling all the increasing commerce of China, Japan, the west coast of the United States and the Pacific countries of South America, Mexico has expended \$8,000,000, silver, in the making of a harbour midway down her western shore line, and will spend something like \$6,000,000 more in perfecting wharves, slips, huge warehouses and other conveniences for the traffic which comes into the Republic from the west.

This port is Manzanillo, and it lies midway down the Pacific shore, about 500 miles from Mazatlan on the north and 600 miles from Salina Cruz on the south. Other Pacific ports, of which there are four—Guaymas, Mazatlan, Acapulco and Salina Cruz—serve limited areas; but Manzanillo is so situated and so connected with the thickly-inhabited tableland of the centre of Mexico by a railway line that its importance is nationwide, and a large proportion of the Pacific trade passes through it.

It is also a half-way station between San Francisco and the city of Panama. In the international commerce following the opening of the Panama Canal, then, Manzanillo will participate to a far larger share than any other Mexican port. Many years ago the rulers of Mexico saw the advantages of this harbour, but it then did not have railway connection with the capital. With the extension of the Mexican Central (now part of the National Railways of Mexico) through the barrancas of the Sierra Madre, however, the project of transforming Manzanillo from a storm-swept bay into a well-protected harbour was taken up in earnest.

Some idea of the monumental task undertaken may be gained from the fact that, though the work was begun in 1899-1900 and has been pushed with all possible speed ever since, the harbour has not even yet been completed, though it is now in condition to receive, and does receive, over its wharves an enormously increased trade. Col. Edgar K. Smoot, the man who built the Galveston jetties, is the contractor employed by the Mexican Government to carry out this great work, and it has been done not only to the satisfaction of the government of the southern Republic, but to that of every steamer line which enters the port and to the great benefit of the people living in interior Mexico.

Manzanillo is one of the ancient ports of Mexico. History records that the Cortez outfitted galleons to search the uncharted Pacific, and that many a pirate ship sailed out of the harbour to attack the laden merchantmen returning from the Philippines and the Farther East. Its background is a crescent of green hills, backed by a line of lofty mountains—the Sierra Madre, of Mexico—out of which rises Colima, the only active volcano on the North American continent.

Manzanillo Bay is situated in longitude 5:08:12.1 west from the city of Mexico and latitude N. 19:03:14.8. It has a total length of 7 kilometres from southeast to northwest, with an average width of 6 kilometres behind the general coast line of the Pacific Ocean.

Investigations made by the engineers prior to commencing actual work on the harbour showed that deep coves were maintained by the



MANZANILLO HARBOR, SHOWING METHOD OF RECLAIMING LAND

currents at both ends of the bay, and that the depth ranged from 30 to 50 metres over the central area, the deep water extending in some places close to the shore. During storms waves in the harbour reached heights of from 3 to 4 metres and broke on the inner shore with terrific force. The history of the port contains numerous instances of disastrous wrecks, and, during the dredging for the harbour works, the remains of a number of vessels were brought to the surface, most of them to remain forever unidentified.

The agreement entered into between the contractor and the Mexican Government called for four improvements:

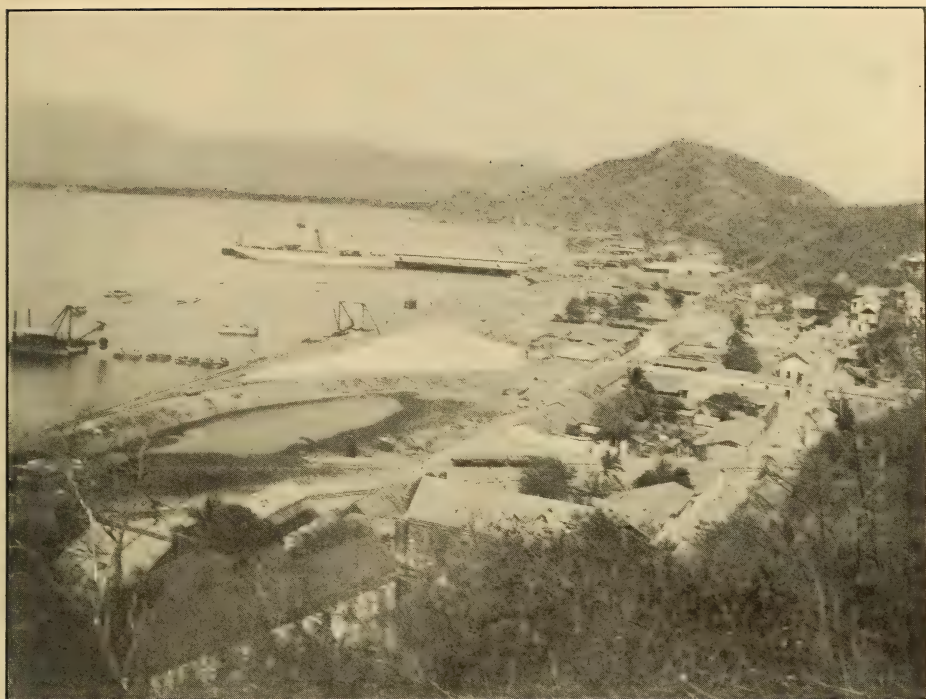
1. Construction of a breakwater to protect the harbour;
2. Dredging of the protected area to a uniform depth;
3. Construction of sea-walls to a height of 3 metres above mean tide;
4. Sanitation of Cuyutlan Lagoon by a canal, to give the lagoon con-

nection with the sea at a point known as Ventanas—that is, the windows.

Two of these stipulations of the contract were purely matters of dredging and deposit of the mud and silt raised from the bed of the bay and from the canal cut at Ventanas. The other two, however, required the use of immense quantities of some durable stone. Investigations disclosed the existence of a large deposit of blue granite of an excellent grade on the Colomo property only about 9 kilometres from Manzanillo.

To handle this, rail connection was made with the port, and, later, an incline was built to deliver the blocks of granite cut at the quarry directly to the wharf and breakwater. The sum of \$1,500,000, silver, was invested in railroads, sidings, houses for the men, and other preparations for the actual work of improving the port.

On March 17, 1900, the formal inauguration of the improvement was held. The breakwater was the first



BACK OF SEA-WALL, AND WHARF ALREADY CONSTRUCTED

consideration, and what to-day stands as a triumph of engineering skill and constructive genius was steadily pushed out from the projecting headland at the southwestern end of the bay.

Thousands of tons of stone, cut in various sizes, were quarried and deposited along the line marked out for the breakwater. Gradually there rose from the waters of the Pacific, from a base 315 feet in width, a solid mass of rockwork, absolutely impregnable to the action of the ocean waves.

The breakwater is 26 metres in height, tapering from the wide base above noted to a crown 8 metres in width. In length it extends 441 metres out into the sea, and is so constructed that it presents an oblique face to the waves, the most direct and powerful of which strike it at an angle of about 36 degrees from normal incidence.

It also serves as a permanent defense against the sands which formerly entered and choked the port

from the coast line to west and south.

Probably the heaviest blocks of granite ever placed by the hands of man were those brought from the Colomo quarries and laid in this breakwater. These monoliths, now capping the outer surface of the Manzanillo breakwater, weigh from 30 to 60 tons, and, when transported from the quarries to the port, each block formed a carload.

Below these masses of granite the outer slope is capped with 30-ton blocks of concrete, made from the best materials obtainable and in accordance with the terms of the contract, which were very specific in detail as to just how these artificial stones were to be made. These blocks were among the most expensive factors in the construction of the entire breakwater.

The interior slope is capped with granite and concrete blocks weighing from 5 to 15 tons each. The crown is a solid deposit of concrete weighing more than 60,000 tons. This cap

forms a monolith 4 metres high, 8 metres wide, and extends for the entire 441 metres of length of the breakwater.

Greatly exceeding in depth and with the famous sea-walls of Cherbourg and Plymouth, no finer or more effective protection for a harbour was ever designed or carried out than the Manzanillo breakwater. It is one of the most important and serviceable works of its kind ever constructed.

The next important step in the improvement of the harbour was the building of the sea-walls for the town of Manzanillo. These have a total extension of 1,869.34 metres, or more than a mile. They have been built 3 metres above the line of mean tide, and are of most substantial construction, protected on the outer slope by blocks of granite weighing from 5 to 15 tons each.

An area of more than 30,000 square metres has been reclaimed from the harbour behind these sea-

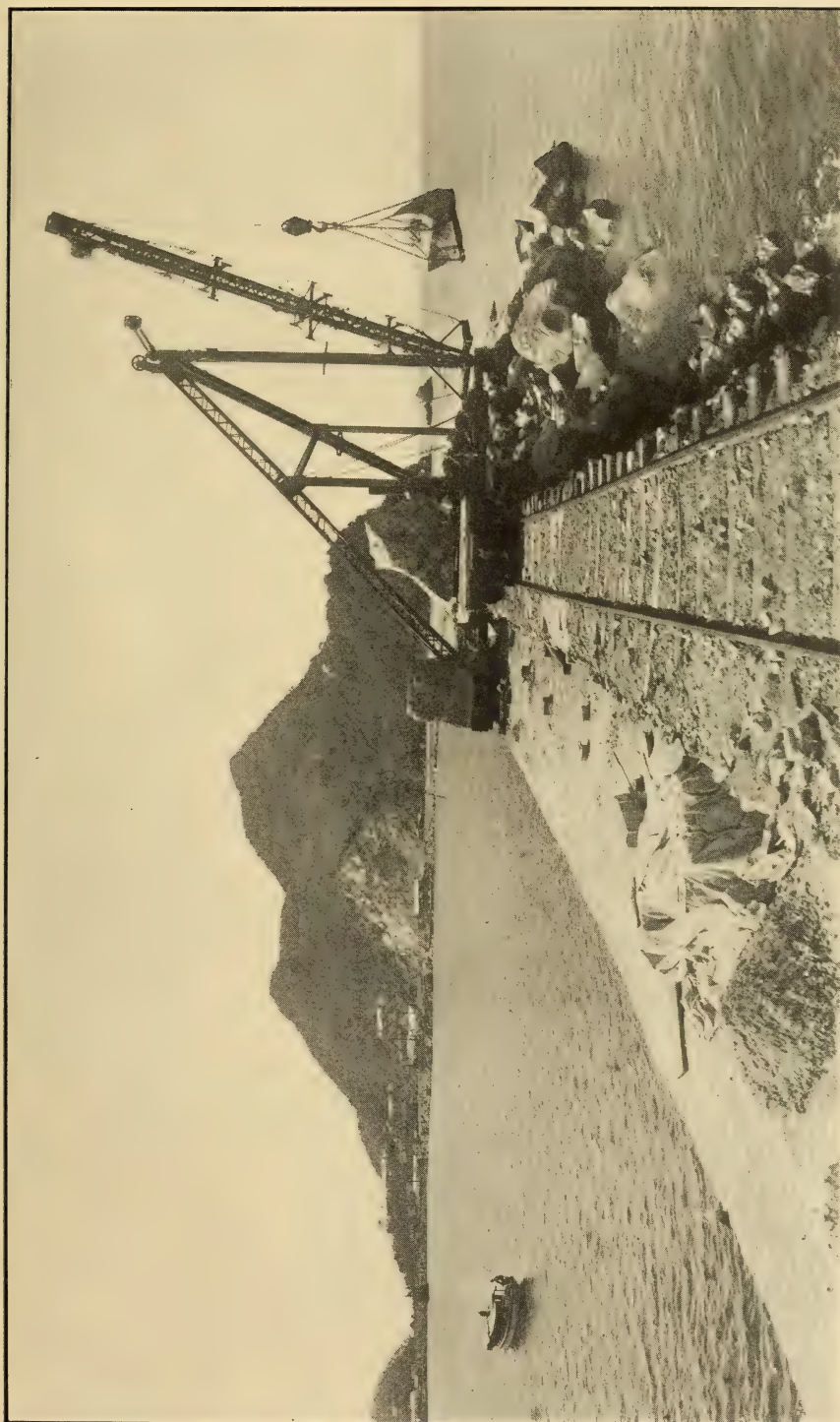
walls by the depositing of coral and other material dredged from the bottom of the bay. A uniform and valuable piece of waterfront has thus been saved for the building of wharves and warehouses for the extensive trade which is already beginning to pour into Mexico through this port.

The contract called for the dredging of the harbour near the shore, where deeper water was demanded for the anchorage of the big freighters to a depth of $8\frac{1}{2}$ metres below mean tide. At the point where the Manzanillo wharves are projected the least depth at low water is now equal to the government requirement, the general depth of the harbour at the present time being 15 metres or more.

The Cuyutlan fresh-water lagoon, which, by its breeding of mosquitoes and production of disease from putrefying vegetation during the summer months has for years been a menace to the health of the port, has been transformed by the Ventanas Canal,



PLACING HEAVY BLOCKS ON THE JETTY



COVERING BREAKWATER WITH HEAVY BLOCKS

which, giving the lagoon connection with the salt waters of the sea, fills and empties it with each turn of tides. The danger to health has been completely removed by this undertaking.

In addition to the canal, a dam was thrown across the lagoon at the Estrecho de Tepalcates, with the object of fostering an important salt industry, which the coming of seawater into the lagoon has established at the eastern end of this formerly land-locked body of water. The dam consists of a puddled core of earth, with revetments of stone on each side and the top.

The approximate cost of the work so far done by the Mexican Government at Manzanillo is \$8,000,000, silver. The breakwater has given to this port a protected harbour of 165 acres—sufficiently large to shelter the navies of many nations. Compared with the cost of other artificial harbours, the cost of the Manzanillo improvements has been very light in proportion to the area.

The great depth of water found over the entire area of the harbour of Manzanillo is one of the most striking advantages of the new port. This factor in the development of this gateway to Mexico is apparent already, but it will become increasingly important with each passing year, as vessels of deeper draft come to unload their cargoes from the Far East, the United States, Canada, and the countries of South America.

The steadily growing draft of the big freighters and passenger ships is already causing considerable anxiety in the supposedly completed harbours of the world, and it was part of the plan of the Mexican Government to dredge the Manzanillo harbour deep enough, once and for all, to permit it to accommodate any ships which might come to its wharves. The breakwater and sea-wall are so constructed that the present depth of the harbour can be maintained without any additional expense, tides and currents being powerless to fill up the

basin. At the International Navigation Congress, held recently at Brussels, Belgium, Manzanillo was given great prominence, being named in the list of the world's hundred most important ports.

The following figures, taken from government reports on the work, will show, to some extent at least, the amount of actual work already accomplished on the improvement of the harbour. What yet remains to be done will be told in later paragraphs:

COMPLETED IMPROVEMENTS

Quantity of stone and concrete used in the construction of the port works, 775,000 metric tons.

Quantity of sand and soft material dredged, 490,000 cubic metres.

Quantity of rock and other hard material dredged, 55,000 cubic metres.

Lumber used in construction, 5,000,000 F. B. M.

Cement used in construction, 37,000 barrels.

Area of protected harbour, 165 acres.

General depth of harbour, 50 feet.

Least depth alongside projected wharves at low water, 28 feet.

Length of completed breakwater, 1,446 feet.

Height of breakwater at outer end, from bottom of bay to top of crown, 87 feet.

Total length of interior sea-walls in present harbour, 6,133 feet.

Length of proposed wharfage, for which plans have been drawn and estimates made, 15,466 feet.

Number of steamships, or other sea-going vessels, which can be accommodated alongside projected wharves, 50.

Number of vessels easily accommodated at anchor or at wharves in present harbour, 100.

Approximate cost of works to November 1, 1910, \$8,000,000, Mexican currency.

Estimated cost of completed improvements, as described below, and including cost of work already done,

\$14,000,000, Mexican silver currency.

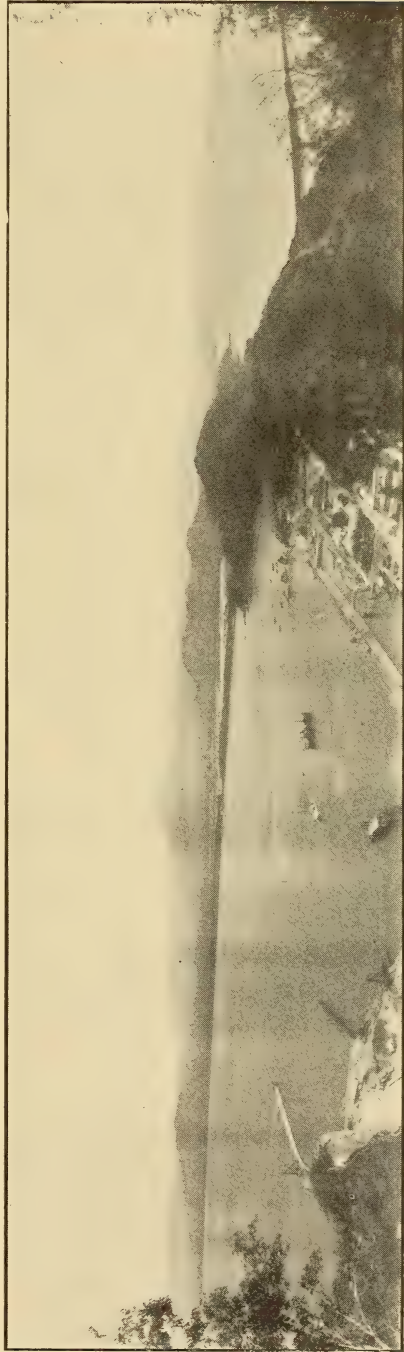
In the project for the extension and completion of the work of improvement of this harbour the breakwater will be extended 200 metres further out to sea. Another breakwater will be built from a point known as La Peñita, on the eastern side of the bay, to a length of 1,054 metres. The ends of the two breakwaters will face each other, with an opening 1,000 feet wide between.

With the building of this second breakwater, the protected area of Manzanillo harbour will be increased from 165 acres, its present size, to 319 acres, or nearly double the anchorage it can now offer.

Great masonry wharves, each 750 feet in length, large enough to accommodate even the leviathans of the Atlantic trade, will project from the sea-wall along the southern shore of the harbour. The crescent of foothills which now wall in the city will be cut down to permit the extension of the town of Manzanillo, and the material so cut off will be used in extending the land possible of reclamation from the waters of the lagoon and from the sea itself.

These are the plans drawn, and, since they represent an expenditure of only \$6,000,000, compared to \$8,000,000 already expended, it is a practical certainty that the remainder of the undertaking will be pushed to as successful a conclusion as has the part already completed. In addition to this, it should be mentioned that the Mexican Government has plans under way for less extensive improvements to the harbours of Mazatlan, in Sinaloa, and Guaymas, the port of Sonora, on the Gulf of Lower California, both important gateways, but of less moment than Manzanillo.

In the government reports for the month of May, 1910, appears a part of the reason for the improvement of Manzanillo. These statistics show that Manzanillo is far in the lead of all the Pacific Coast ports in point of imports. The figures are as follows:



PANORAMA OF HARBOUR OF MANZANILLO AND LAGOON WHICH WAS DRAINED



BREAKWATER WHILE UNDER CONSTRUCTION, NOW COMPLETE

Manzanillo	\$582,573.47
Santa Rosalia (Boleo Copper Co.)....	462,893.27
Guaymas	249,600.15
Mazatlan	244,686.50
Salina Cruz	144,400.09
Acapulco	46,614.21
San Blas	22,431.67
Topolobampo	16,249.98

The construction of the Manzanillo extension of the Mexican Central Railway, now part of the great merger system known as the National Railways of Mexico, from

Tuxpan, Jalisco, to the port, a distance of only about 100 miles, required more than three years of continuous work and the expenditure of about \$10,000,000, gold, making it one of the most expensive pieces of railway construction, mile for mile, ever attempted in the world.

This line, the first direct rail connection between interior points in



VIEW OF COMPLETED PORT OF MANZANILLO

Mexico and the Pacific Coast, was formally inaugurated by Gen. Porfirio Diaz, President of Mexico, in December, 1908. The line was thrown open to traffic immediately thereafter, and is now one of the most important branches of the merger.

The completion of the Manzanillo extension opened the markets of Mexico to Pacific commerce and gave Mexico access to the Pacific ports of the United States, British Columbia, Central and South America and the Far East. Since the construction of the harbour improvements at Manzanillo became far enough advanced to permit of active use, the commerce of the port has advanced 600 per cent., this period being about two years, or from the opening of the Manzanillo extension of the Mexican Central, mentioned above.

Manzanillo is now in direct touch with the "granary of Mexico," the fertile State of Jalisco, the most densely populated and most productive of all the Commonwealths of the Mexican Union. Guadalajara, the capital of this State, is the second city of the Republic in population and the first in point of commerce and manufactories. An enormous supply of hydro-electric energy is available from streams around Guadalajara, and, in commerce and manufacturing, it is sure to dominate the Pacific Coast for many years. The bulk of this city's commerce will always pass through Manzanillo.

The steamship service in and out of Manzanillo is as good as that of any Pacific Coast port of the New World, not even excepting San Francisco. It is visited at frequent and regular intervals by ships of the Pacific Mail (American), Southern

Pacific (American), Naviera del Pacifico (Mexican), Kosmos Line (German), Canadian-Mexican Steamship Company (Canadian), Chargeurs Reunis Line (French), Toyo Kisen Kaisha (Japanese), Jebsen Line (German), and the Eng Hong Fong Steamship Company (Chinese). In addition, many tramp and independent steamers call there. Manzanillo is the port of entry for Asiatics, and secures the bulk of the Oriental trade.

In addition to the improvement of the port, a concession has been granted to Col. E. K. Smoot, builder of the port works, for one of the most complete coaling stations on the Pacific Coast of the New World. This plant will be so situated that the largest vessels in the Pacific trade can tie up alongside its wharves and take on fuel direct from the chutes. The station will have an initial capacity of 500 tons per hour. Manzanillo alone, of all the ports of Mexico, will enjoy this possession of a coaling station, at which, according to the concession, ships of foreign navies may take on fuel. This will be a feature of great weight in the future commercial supremacy of the port.

Included in the plans for the complete improvement of the harbour, also, are plans for modern water-works and a perfect drainage system for the city of Manzanillo itself. The connection of the lagoon with the sea, described above, has removed the source of the malaria and fever which once was the curse of this port, and, with fresh mountain-water brought from the Sierras, the great west-coast port will become, not alone a commercial gateway, but a delightful place in which to live as well.

DUST, SOOT AND SMOKE

SCIENTIFIC METHODS OF ESTIMATING THE DUST AND SOOT IN THE ATMOSPHERE AND THE DENSITY OF CHIMNEY SMOKE

By John B. C. Kershaw

THE increasing attention now being given to the allied questions of smoke-prevention and the improvement of the purity of the atmosphere in all large towns renders the introduction of correct and scientific methods of recording the amount of dust and soot suspended in the air and the blackness or density of the smoke emitted from factory chimneys of the highest importance.

In the past there has been no attempt made to obtain comparative and permanent records of this kind on the part of the health or sanitary authorities of any town, and "smoke prosecutions" at the present date are still too often based upon incorrect or unscientific evidence. The first step in any reform of the existing system is to show that more satisfactory and scientific methods of observation have been developed and are now available for general use. In the first portion of this article several methods of estimating the amount of soot and dust held in suspension in the atmosphere will be described, while in the second section of the article the newer methods of observing and recording the density of the smoke emitted from individual chimneys will be dealt with. Until the health or sanitary authorities of all large towns and cities take up the study of smoke-emission in this manner their statements regarding the degree of purity or otherwise of their towns' atmosphere must be accepted with some reserve, for there is no subject of common observation upon which independent observers are more disposed to differ than upon the comparative density of the smoke emitted

from their own and their neighbour's chimneys, or the relative purity of their own town's atmosphere as compared with that of their nearest rival. The personal factor must, in fact, be removed before accuracy can be hoped for or arrived at.

I.—Scientific Methods of Estimating the Amount of Soot and Dust in the Atmosphere of Towns and Cities.

A.—RUBNER'S METHOD

The Rübner method of soot and dust determination is based upon the aspiration of a large volume of the air which is to be tested (200 to 300 cubic feet) through a filter paper placed in a special holder. Upon the surface of this paper the soot and dust are collected. (Fig. 1 a.)

The aspiration is effected by a water-jet pump, and the volume of air is measured by an ordinary dry meter. The determination of the amount of soot and dust collected on the paper in twelve or twenty-four hours is carried out by comparison with a standard scale, since the amount is too small, even with the large volume of air used, to be determined by direct weighing. Renk has employed for the comparison a mixture of a known amount of soot and oil which, when used in a glass vessel of wedge-shaped design, gives a colour scale of gradually increasing density. This method of estimating the soot and dust in the atmosphere is now being employed by the officials of the Hygienic Institute in the city of Hamburg, the results being carefully recorded. It is stated that a series of these tests will shortly be published.

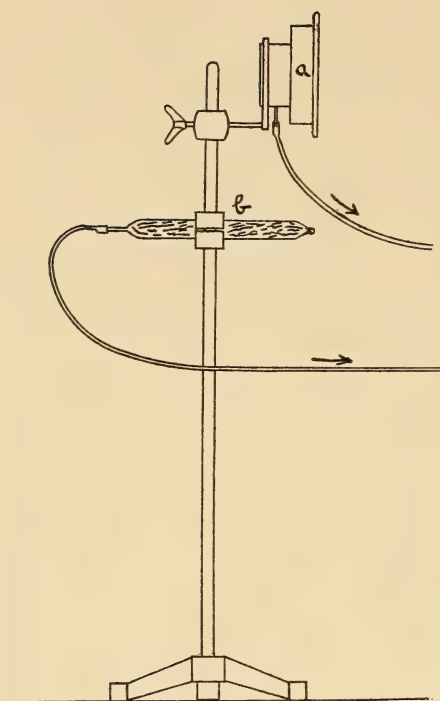


FIG. 1.—THE RUBNER AND HAHN APPARATUS

B.—HAHN'S METHOD

The apparatus devised by Hahn consists of a double-cylinder pump, worked by an electric motor with current from accumulators. The volume of air in this case is ascertained by multiplying the cubical capacity of the two cylinders of the pump by the number of revolutions of the crankshaft, as recorded by a counter attached to the same. The soot and dust are retained by drawing the air through a tube containing collodion wool. (Fig. 1 *b*.) The estimation of the soot and dust is made by dissolving this collodion wool with its deposit of soot and dust in a mixture of two parts of ether and one part of alcohol. The final step is to compare the turbid fluid thus obtained with various standard solutions containing collodion and known amounts of soot and dust. The apparatus for carrying out this method is more costly than that of Rübner, and the use of ether adds considerably to the expense of the final comparison.

C.—LIEFMANN'S METHOD

Liefmann's method differs essentially in principle from the two methods already described, since it is based upon deposition or "sedimentation" of the soot and dust particles upon prepared plates and not upon filtration.

The method is described in considerable detail in the "Habilitationsschrift" (Degree Thesis), published by Liefmann on taking his degree at Halle University, in 1907. Considerable space is devoted in his pamphlet to the theory of "sedimentation" as a means of measuring the soot and dust particles suspended in the air and to the reasons why *two surfaces* are necessary (a vertical one and a horizontal one) in order to obtain correct results. The practical operation of the method only can be described in this article. The apparatus required is simpler than in the case of the Rübner and Hahn methods, and it is, therefore, more easily moved from place to place or erected at any desired point of observation. A firm, three-footed base of cast iron is provided with a vertical centre rod or spindle. This carries a horizontal plate on the edges of which are fixed four thin uprights carrying a light roof or cover. Under this cover is fixed the vertical disc of glass covered with a thin film of oil for catching and retaining the particles of soot and dust blown by the wind in a horizontal or inclined direction. These particles would not be caught by the horizontal disc fixed on top of the apparatus, since only the particles falling in a vertical direction impinge on this disc. The vertical plate must, of course, be kept facing the wind or air current, and for the purpose of causing it to turn with any change in the direction of the wind a large vane is fastened to the back of the spindle which carries it. (Fig. 2.) The glass discs used by Liefmann in his trials of the method were the usual chemical clock glasses 100 square centimetres in superficial area, and the oil film was obtained by paint-

ing their concave surface with a perfectly white-bleached oil by means of a small brush.

After twelve or twenty-four hours', or longer, exposure to the atmosphere the two glass discs are removed from the apparatus and newly-prepared ones are inserted, if the observations are to be continued. The exposed discs, with their films of soot and dust-covered oil, are then held over a small glass mortar, and the film is removed by aid of ether, which dissolves the oil and holds the soot and dust in suspension.

This ether solution is then evaporated by placing the mortar containing it in a warm place. It is most important to note that no light must be near this place, and that, as ether-vapour is heavier than air, it flows *downwards*. The residue is then rubbed up with 5 cubic centimetres of the originally used oil, in order to yield a mixture for comparison with the standards. These standards are prepared by taking a weighed quantity of dry soot prepared from naphthaline and by mixing this carefully with 5 cubic centimetres of white bleached oil in a glass mortar. These mixtures are then placed in a series of glass-stoppered tubes having flat feet, the quantities of soot used giv-

ing a scale reading from 1/10 mg. up to 5/10 mg. While the first tube of the scale is only slightly tinged a dark colour, the last tube will be perfectly black, and the difference in tint between successive tubes of the series is clear and distinct. The oil-and-soot mixture obtained from each of the exposed discs is now placed in a similar glass-stoppered tube and is compared with the standard tubes, in order to determine the amount of soot in suspension. The results must be calculated upon 5 cubic centimetres of oil and multiplied by 100, in order to give the quantity of soot falling upon an area of 1 square metre (10.75 square feet) during the time of exposure.

According to Liefmann, a test by this method can be completed in ten minutes, exclusive of the time taken for the evaporation of the ether; the accuracy is within 0.05 mg.

The following are some of the figures obtained in Hamburg in the winter of 1903-04 by this method:

		Results Calculated Upon One Square Metre and 24 Hours.		Remarks.
Date	Weather.	mg.		
1903.				
Dec. 18. . .	Bad. . . .	23. 59		On horizontal disc.
Dec. 18. . .	Bad. . . .	18. 85		On horizontal disc.
Dec. 19. . .	Bad. . . .	18. 94		On horizontal disc.
Dec. 19. . .	Bad. . . .	16. 14		On horizontal disc.
1904.				
Jan. . . .	15 Windy. . .	183. 45		On vertical disc, wind blowing from harbour.
Jan. 22-23	Good. . . .	35. 29		On horizontal disc.
Jan. 23-27	Moderate	298. 70		On horizontal disc.
Jan. 24-25	Moderate	76. 40		On vertical disc.
Jan. 24-25	Moderate	19. 11		On horizontal disc.
Jan. 27-28	Moderate	69. 60		On vertical disc.
Jan. 27-28	Moderate	13. 90		On horizontal disc.

The above tests show that, as a rule, more deposit is collected on the vertical surface than on the horizontal one, which is in accordance with the theory of the sedimentation process, since on most days there is sufficient motion of the air to cause a drift of the dust and soot particles in a horizontal direction. On perfectly calm days the horizontally-placed surface will collect the larger portion of soot and dust.

II.—New Methods of Observing and Recording the Density of Chimney Smoke.

The need for more scientific and

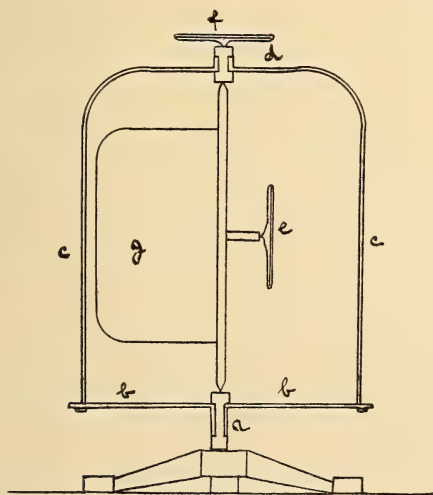


FIG. 2.—LIEFMANN'S APPARATUS

accurate methods of observing and recording the density of the smoke emitted from factory and works chimneys was well brought out in the address delivered by Mr. James Swinburne, F.R.S., before the Association of "Engineers in Charge" in October of last year. In the course of some comments upon the evidence given in "black-smoke" prosecutions under the existing acts, Mr. Swinburne made the following very pertinent remarks:

"Smoke records are, naturally, chiefly of use in giving evidence about smoke, as, without them, the magistrate has to decide whether there has been 'black smoke,' or smoke amounting to a nuisance, from the evidence of a number of witnesses called on each side. This is rather apt to be unfair to the defendant, because the prosecution can bring evidence that, at such a time, on such a day, a witness saw 'black smoke.'

"The defendants had not their attention called to the smoke at that moment, and all they can do is to give evidence that at other times they did not emit 'black smoke,' or that their furnaces are so good that they do not believe they ever emitted 'black smoke.'

"The great difficulty is that, up to now, there has been no way of making any sort of estimate as to the blackness of the smoke. One witness may say, quite fairly, that he considered the smoke dense black, while another witness, quite as fair, looking at the same smoke, may say it is only gray or, at the most, dark gray smoke. There must always be the difficulty that the witness for the prosecution sees the smoke of which there is complaint without the defendant being able to produce any evidence about it."

Within recent years several instruments have been devised for overcoming this difficulty and for eliminating the unsatisfactory personal factor from the observation of the smoke emitted from the chimneys of factory

or works. These will now be described seriatim.

(a)—THE SWINBURNE PHOTOGRAPHIC SMOKE-RECORDING APPARATUS

A full and detailed description of this method and of the apparatus required for carrying it out was given by the inventor in the issue of *The Times* (Engineering Supplement), of March 20, 1907. The following description is drawn from that article, the "smoke-scale" referred to being that issued by the committee of the Institution of Civil Engineers in their "Report on Steam Engine and Boiler Trials," published by Messrs. Clowes & Co. The principle of the method is that of photographing the smoke-scale and the smoke upon the one plate, so that any variation in the depth of tone of the negative, due to the method or time of exposure, or to the methods and chemicals used in developing will affect both the chart and the smoke equally, and a fair comparison will be obtained between the two. As Mr. Swinburne says:

"To photograph the smoke in the ordinary way would be quite useless as a record, because the appearance of the smoke in the resulting print would depend on the kind of plate used, whether it is slow or fast; whether it is isochromatic, and used with or without a screen; how far it is developed, and whether the negative is intensified. Then the print may be on a print-out paper giving great contrast, or on a platinum one, or a bromide paper may be used, properly exposed and fully developed, or over-exposed and incompletely developed. Most of these sources of error can be completely avoided by photographing the smoke-scale with the smoke. They then both receive the same treatment, and the smoke on one print is compared, not with the smoke on another print, but with its own smoke scale. This smoke on one print may be very light. The scale is then very light, too, so that the smoke corresponds with the scale at, say, 0.4, which means that the

smoke stops four-tenths, or 40 per cent., of the light. On another print taken by someone else at the same time the smoke may look very dark; but the scale will look very dark, too, so that the smoke will still correspond with the part of the scale marked 0.4.

The scale is made by putting a process plate in a printing frame with a paper screen in front of it. This screen has a rectangular hole to correspond with the smoke scale. The hole is covered by a paper shutter, which is withdrawn in steps. A division into eight steps is probably as many as will ever be wanted. For a process plate a candle, about 2 feet off, will do. The exposures for eight grades will then be sufficient if the first tint is exposed 64 seconds, the second and first 32, and so on. This gives exposures of 1, 2—128 seconds in geometrical progression. There is no special reason for exposing in geometrical progression like this, but photographers always do it. The finished plate is then clear glass, except that there is a scale along one side, so as to be in the sky in a photograph. The scale plate is mounted in the camera so as to be in front of the sensitive plate. It may be loose, so that when the camera is held lens upwards it falls right on to the sensitive plate. On turning the camera with the lens down, it falls back on to stops in the camera frame. A film camera would most likely be more easily fitted.

"A cheap pocket quarter-plate camera does quite as well. Unfortunately, the shutters have generally only one speed, chosen for beginners' home portraiture, and this may be far too fast for practical smoke and sky work in this climate. In taking the chimney the camera is held so that the smoke comes close to the scale. To get good results, the smoke should be taken against a background of uniform sky. Fortunately, it is easy to get a uniform dull gray sky in this country."

(b)—LOWDON'S SMOKE TINTOMETER

This instrument is comparatively simple in construction and use, and will be found of value in making the preliminary observations of the blackness of the smoke issuing from a chimney before attempting to obtain a photographic record of the same by the Swinburne method and apparatus.

For it may be noted here that the emission of dense black smoke from most factory and works chimneys is *periodic in character*, and that if a chimney is observed closely it will be found that the periods (of longer or shorter duration) when dense smoke is emitted agree very closely with the periods during which fresh fuel is being thrown upon the fires. If black smoke is then observed issuing from a chimney at 11 o'clock A. M., say for a period of one, two or three minutes, it is probable that smoke of the same density will again be emitted at 11:15 or 11:30, according to the interval between the times of firing. The smoke inspector or observer having once decided that the chimney is an offending one under the local acts, by observation with such an instrument as the Lowdon tintometer, can then proceed to obtain a photographic record of the smoke by the Swinburne method and apparatus.

Lowdon's apparatus consists of a metal tube having at one end an eyepiece and at the other end two apertures. One of these is fitted with a revolving diaphragm, by means of which it is possible to bring different pieces of tinted glass in front of the aperture. The diaphragm has six holes, corresponding in size to the object aperture, and five of these are provided with tinted glasses of varying density, marked No. 0 to No. 5, according to the scale of the well-known Ringelmann smoke chart.

"In estimating the density of smoke with this instrument the observer approaches as close to the chimney as will enable him to see through the observing aperture of the instrument

a circular disc of smoke without any of the surrounding sky. The instrument is held so that the other aperture is to the windward side of the smoke column, and by revolving the diaphragm the observer can match the varying densities of the smoke as it issues from the chimney top."

(c)—BONHAM AND WEBER'S METHOD

The two methods of observing and reading the density of the smoke described above are not continuous in character, and are further handicapped by the fact that an *observer* is required to operate them.

Messrs. Bonham and Weber have devised a continuous and automatic method of recording the density of smoke issuing from a chimney which is well worth installation in every large works, since the records obtained with it can be of great assistance and value in the general oversight of the firing of all boilers and furnaces.

A perforated ring pipe is inserted in the main flue or breeching at the base of the chimney, and from this point a small proportion of the gases passing up the chimney are abstracted by an electrically-operated fan or pump, and are forced under pressure to the point where the recording apparatus is installed. This should be near to the chimney, to prevent deposition of soot in the pipe, and the flow of gas should be rapid.

The apparatus consists of two large drums revolved by clockwork and of a long piece of white tape, chemically treated to retain the soot and dust. The tape is wound upon one drum and the free end is attached to the second drum in such a manner that the chemically-prepared surface of the tape stretched between the two drums is upwards and is exposed to the chimney gases as they issue, *under pressure*, from a narrow opening in the mouth of the pipe which leads them to the apparatus.

The clockwork and the electric pump are then set in motion, and the apparatus is left working for a period

of twelve or twenty-four hours, when the tape wound upon the second drum is cut off and is removed and examined for its record of soot and dust. It is obvious that this apparatus must be enclosed in a dust-proof cupboard and be kept under lock and key, in order to obtain accurate records. A still simpler modification of this method consists in the use of the tape without any chemical treatment, the record being obtained by drawing the tape *tightly stretched over the orifice in the smoke pipe* and by employing sufficient pressure in pumping the gases to force them *through* the tape.

(d)—METHODS FOR GUIDANCE OF THE FIREMEN AND BOILER ENGINEERS

A difficulty which handicaps many firemen in the discharge of their duties is that the chimney top is quite out of sight from the firing plate of the boilers, and that they have no means of knowing, unless they leave their boilers and go outside the boiler house, whether black smoke is being emitted or not. The simplest method of overcoming this difficulty in those works where it exists is to cut openings in the boiler shed and to fix silvered glass mirrors at one or two points on walls, so that the fireman can see the chimney top, either directly or by reflection, *without leaving the firing plate of the boiler house*. The writer first saw this arrangement in Gallagher's tobacco factory, in Belfast, in 1902, and it has now, on his suggestion, been adopted in many works in the United Kingdom and in America. When this plan is impracticable, owing to the large size of the works and to the number and height of the intervening buildings, that proposed by Messrs. Bonham and Weber should be adopted. The mechanism already described in Sub-section C is utilized not only to supply a sample of the smoke-laden gases to the recording apparatus, but a portion of the gas is forced through a small chimney stack erected in a convenient spot on the floor of the

boiler or furnace house, and the top of this miniature chimney is provided with a white background, so that the colour of the smoke and issuing gases can be instantly seen.

It is necessary, however, when this method is adopted to arrange that the volume of exit gases traveling to the smaller smokestack shall be proportioned to its smaller diameter in relation to the larger one; otherwise, the indications will be wrong. With this device, both the firemen and the engineer in charge of the boiler or furnace house will have constantly under their eyes an indication of the density of the smoke emitted from the chimney of the works. Allowance will, of course, have to be made for the difference in the diameter of the

two chimneys. A column of smoke which appears brown when seen through a depth of 6 inches will seem to be much darker, and may even appear quite black, when viewed through a depth of 6 or more feet, and the firemen will have to regard the slightest sign of smoke at the top of the chimney stack as indicative of a much worse effect at the top of the works chimney. However, there is not the slightest doubt in the writer's mind that, if every boiler house possessed this simple addition to its equipment, there would be a great diminution in the amount of black smoke emitted from the chimneys of works and factories on both sides of the Atlantic, to the material benefit of the surroundings.



THE RAILWAYS OF BRAZIL

By Lionel Wiener

X.—THE MOGYANA RAILWAY SYSTEM

THE Mogyana Railway, which obtains its name from the river district of the same title, is one of the three large companies in the State of Sao Paulo, stretching even beyond the northern boundary and over into the State of Minas on the east. The road does not reach Santos or Sao Paulo at all, but branches off from the Paulista line at Campinas, 28 miles beyond Jundi-ahy, which is 115 miles from the port of Santos over the Sao Paulo Railway. These connecting lines are built to the broad gauge, 5 feet 3 inches, while the Mogyana system is laid on the metre gauge, and keeps east of the Paulista Railway and of the Mogy Guassu river and the Rio Pardo.

The main line is a penetration one, running nearly due north toward Catalao from Campino, on the 23d degree of latitude, to Araguary, latitude 18 degrees 30 minutes, in the belt between 3 degrees 50 minutes and 5 degrees west of Rio. This includes a stretch of 498 miles, which, with the 115 miles down to Santos, makes a total run of 613 miles.

This line is a fair sample of the many ways in which railways are conceded in Brazil. A bill authorizing "a company" to build the first portion, from Campinas to Mogy Mirim, a distance of 48 miles, was passed in March, 1872. The line was granted the usual 19-mile protected zone on either side on a ninety-year lease, with a 7 per cent. guarantee of interest on a maximum capital expenditure of £297,679. The Mogyana Company for Railways and Navigation was floated in the following

year, and the contract for building the line, together with a short branch to Ampara, was signed in June, 1873. An extra clause was added, allowing the company to build the line on "to a convenient point on the northern frontier of the State." The reimbursement of the loans of the Province were to begin after 10 per cent. interest had been paid. Work was begun immediately, and, although the bridge across the Jaguary caused some delay, the line and the Ampara branch were opened in 1875.

The next portion, to Casa Branca, had a similar lease; but the reimbursement was to take place after 7 per cent. dividends had been reached. Onward, towards Jaguara, the line is held on a government lease of fifty years, with a zone of only 12 miles, and a guarantee of interest of 6 per cent. on \$694,444. The Casa Branca extension had been granted in 1875, and was opened in 1878, giving an additional 61 miles.

In 1880 the Paulista Railway had already reached the Rio Claro, and when the Mogyana line was extended through Sao Simao to Ribeirao Preto trouble began, because the latter town was really in the protected zone of the Paulista Railway. This matter and the Santa Cruz line of the Paulista Railway form the causes of continual dissensions between the two companies. The Ribeirao Preto line, originally intended to be a branch, turned out to be the main line to the north. It is 91 miles in length, and was opened to traffic in 1883.

Owing to the neighbourhood of the Paulista Railway on the west, all the branches of the Mogyana line run



MAP OF THE CENTRAL GROUP OF RAILWAYS, SHOWING THE MOGYANA SYSTEM

eastward to the frontier of the State of Minas Geraes. In 1880 such a branch was conceded to Rio de Peixe, which name was changed on the opening of the line in 1882 to Penha, and subsequently to Itapira, which latter name it still retains. When the further extension of the main line was granted to Jaguara, in 1883, the government included a branch to Pecos de Caldas, a frontier and important watering-place. The Jaguara extension and the Caldas branch are the only two sections which have been granted the

6 per cent. guarantee by the government of the Union during twenty years. The Caldas branch was opened in 1886, and during that year it reached Batataes, 234 miles from Campinas.

Franca, a very important town at the 263d mile, was reached in the following year, and Jaguara, 319 miles, on the São Paulo bank of the Rio Grande, in 1888. In the latter year the company purchased the Rio Pardo Railway, extending from Casa Branca to Mococa, with a branch to the frontier of Minas, towards Guaxpe.



OFFICES OF THE MOGYANA RAILWAY COMPANY, CAMPINAS

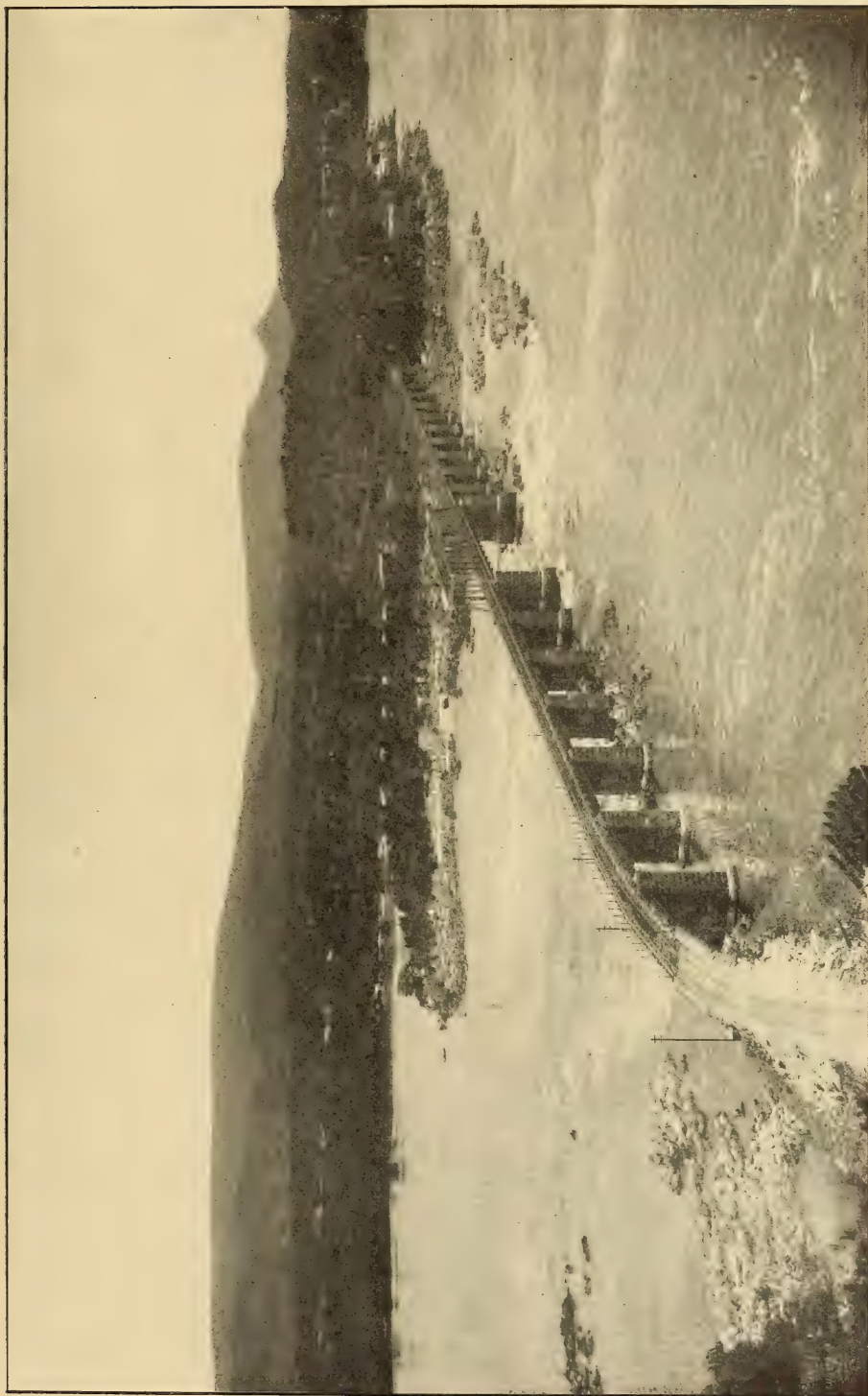
This line, originally purchased simply to extend the protected zone, has recently gained considerable importance, as Guaxpe will probably become the terminus of the Muzambinho Railway, which the company had intended to purchase.

With this end in view, the company purchased the short branch of 10 miles to Guaxpe in 1898, so as to set foot in the State of Minas. In 1908 a line was granted to Mr. Ribiero de Valle, extending from Guaxpe to Muzambinho, a distance of 30 miles. This line formed the only missing link between Mogyana and the Muzambinho systems. The Mogyana Company opened negotiations with the Minas Government, the lessee, and the Government of the Union for the purchase of the Muzambinho and the Rio & Minas Railways for the sum of \$750,000. The matter was referred to a commission, which considered it for several years, and finally refused this

offer, and the lines were handed over to the Sapucahy Railway Company instead.

The object of the Mogyana Railway in the purchase of the South Minas system was the diversion of its traffic north of Casa Branca over the new route to Cruseiro, and then on to some neighbouring sea harbour, thus giving an outlet entirely over its own tracks. The fact that the Mogyana has been obliged to run over the line of its old rival, the Paulista, is a very sore point, and for years the Mogyana Company has endeavoured to run a through line down to Santos. After a hard fight, this was granted in 1893, and the line is planned to start from Resaca, 34 miles from Campinas. The length will be 149 miles, about the same as that through Campinas and Sao Paulo, but a rack section will be necessary down the Serra do Mar.

Notwithstanding all the arguments in its favour, such a line does not



THE MOGYANA RAILWAY BRIDGE OVER THE RIO GRANDE

seem advisable. The existing route of the Sao Paulo Railway can handle more than double the traffic it now does, while the competing line of the Mogyana Railway would have only one-third of the present traffic of the Sao Paulo. It is true that the Mogyana Railway can compute exactly the tonnage upon which the new line can count, which is exceptional, as such tonnage is usually purely hypothetical. Both routes would have a reduced traffic, and the ratio of expenses to gross earnings would necessarily be much higher than at present. The new line would also be difficult and costly to operate, as is already found in connection with the rack sections of the Leopoldina Railway, and even should the Sorocabana road also build its Santos extension, the Sao Paulo Railway would still be the only route to Sao Paulo, and the Paulista would be able to compete successfully with its rivals. Under these circumstances, in spite of the work having been already started, the survey was abandoned and another one started.

This new extension is to start from Mogy Mirim instead of Resaca, and keep closer to the frontier, thus running around Braganca, the terminal of the short line from Campo Limpo. This line now belongs to the English Sao Paulo Railway, and has a protected zone in which no foreign railway may compete for traffic. If the new extension had run across this territory instead of around it, there would have been a long stretch of dead line, so far as local traffic is concerned.

The Serra portion is planned for a double track, the remainder to be single track, with 60-pound rails up the Serra, and metal sleepers, as usual on rack railways. There will be a large station at the top of the incline, with twenty tracks, and thirteen stations along the new road, which will be connected to the Sao Paulo line of the Central Railway of Brazil by a short branch running to the town of Mogy das Cruzes.

The Mogyana Railway has decided to issue debentures to the extent of \$5,000,000 towards building this line,



REVERSING Y ACROSS THE RIO CAMANDOCAIO. SOCCORRO BRANCH OF THE MOGYANA RAILWAY

at the same time raising the capital account from 70,000,000 milreis to 80,000,000 milreis. The company hopes to work the extension at a cost of 40 per cent. of the gross earnings, which would leave a margin sufficient to pay dividends of 12 per cent. on the capital of 40,000,000 milreis; but it is probable that the working expenses have been underestimated.

Apart from the desire to own an

is its intention to build the following lines:

(a) From the main line to Sao Sebastiao de Paraizo, as it is now doing, and on to its own line, north of Jaguará and eastwards to Monte Bello;

(b) Another line through Passos, joining up northward;

(c) The Lavras branch, running through Sao Loao Nepomuceno and Tres Pontas towards Fluvial, and an-



VIADUCT ON THE CALDAS BRANCH OF THE MOGYANA RAILWAY

alternative route to the sea coast there is another reason why the Mogyana Company desires to purchase the Muzambinho system, and this is the creation of new traffic and the diversion of as much as possible of this to Sao Paulo. This would be accomplished not only through the Muzambinho & Guaxpe line, but also through the building of a new system of lines. The writer has reason to believe that, if the Mogyana secures control of the Muzambinho, it

other extending it through Sao Antonio de Machado, which would reach the Mogyana system in Caldas, and so on down to Sao Paulo or Santos.

The writer has gone into some detail about this amalgamation and southern extension because it is one of the most important railway questions which has arisen in Brazil for many years. The outcome might be the actual preponderance of the Mogyana Company in Central Brazil, which would have the very greatest



VIEW ON THE SOCCORRO BRANCH OF THE MOGYANA RAILWAY

repercussion on everything pertaining to railway politics and finance.

It is true that the Minas group has just been leased to the Sapucahy Railway, despite all that the Mogyana could do to prevent it, but the grouping of these Minas lines is not stable; the west of Minas is still practically untenanted, the South Minas Railway has no outlet to the sea coast, and the lines which it must build are of such magnitude that another rehandling of the systems seems to be the only way out of the present situation.

The western portion of the Sapucahy line is bound to be severed and to be joined to the west of Minas extension towards Rio; while, on the other hand, the western portion of the new South Minas Railway belongs, economically, to the Mogyana. This is so true that the building of these western lines has been handed over to the Mogyana. These are the lines from Monte Bello to Muzambinho, Guaxpe, Sao Sebastiao de Paraíso and Santa Rita, with a branch to Areado.

In the meantime, the Mogyana has

been increasing the number of branches from its main line, not only to serve the neighbouring country the better, but also to prevent foreign roads from intruding into its territory. This it has accomplished by building a certain number of branches and in buying up all but one of the lines which had been grafted on to its own by foreign companies. These may be enumerated as follows:

(a) The Pinhal branch from Mogy Guassu was opened in 1889. The Amparo line was next lengthened to Monte Alegre (11 miles) in 1890, and again to Soccorro in 1908. The inauguration train was entirely built in the Mogyana's own workshops, even including the locomotive, one of three, the only ones, so far, to have been built in Brazil. The Federal Government has granted the company a subsidy of 15,000 milreis for the encouragement thus given to national industry. This is mistaken policy, however, as these locomotives are bound to be more expensive than the imported ones, and the money thus spent upon them could be put to better use elsewhere.

(b) Serra Negra, 25 miles off this branch, has been connected with it by a 23½-inch gauge line, the first narrow gauge line on the Mogyana system.

(c) Two other lines have been considerably extended: the Penha branch has been lengthened by 17 miles in 1891, so as to reach Eleutorio, on the frontier, and so connect with the long Sapucahy line to Soledade and Passa Tres.

(d) The northern line, the trunk route, has been extended as well, crossing the Rio Grande river on a fine bridge between Jaguará and Sacramento into the State of Minas Geraes, and stretching away north to Uberaba and Araguary, 613 miles from Santos. It should have been continued to Catalao, beyond the Parana river; but, though there are but some 100 miles to be built, the intervening stretch of country is of so prohibitive a nature that Araguary has remained the terminal all these years, and it was only in 1910 that the Goyaz Railway Company undertook the building of this extension, over which the Mogyana Railway forfeited its claims.

(e) Beyond Ribeirão Preto, the line to Jaguará and Catalao begins

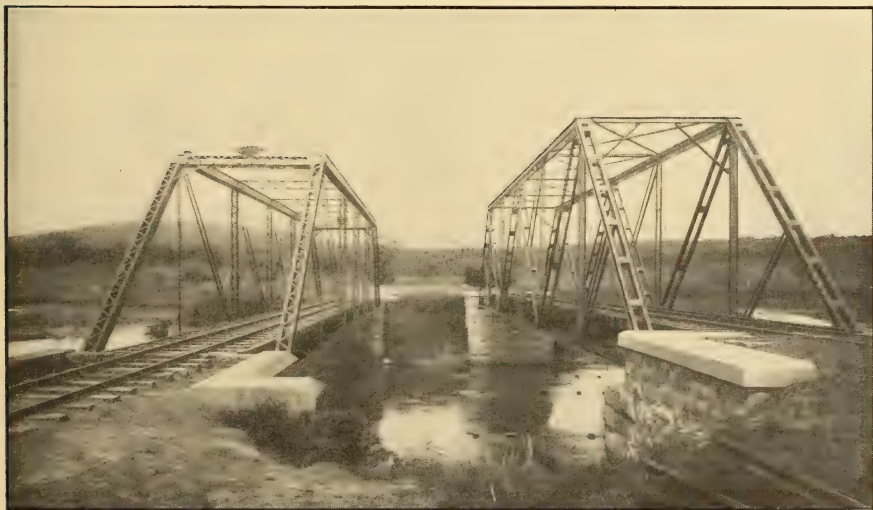
by curving eastwards, and runs westward again beyond the Rio Grande river towards Uberaba. Besides following so roundabout a route, it is not a good line, nor does it pass through the best part of the country.

Another northern line has, therefore, been built, from Ribeirão Preto due north, remedying these defects. It reaches the Rio Grande River at Santa Rita, and would be considerably shorter to Uberaba, but it has not been continued.

(f) A branch from Vassoural to Sertãozinho and to Francisco Schmidt's important coffee estate was opened in 1908. It is 21 miles long, and its terminal is near enough to the Paulista Railway line for a connection between them to take hardly more than a couple of months' work. Yet the two lines begin by turning their back upon each other, and it is only after a 281-mile run that they are obliged to join, at Campinas.

(g) The latest increase in mileage is the outcome of the absorption policy the Mogyana has lately been pursuing.

After having bought the Guaxupé line, Minas section, for 680,504\$, it purchased, in quick succession, the Santos Dumont Railway (743,322\$),



DOUBLE TRACKING THE MAIN LINE OF THE MOGYANA RAILWAY. BRIDGES OVER THE RIO CAMANDCAIO



BRIDGE OVER THE RIO JAGUARY

the Vargem Grande Railway (522,549\$), and the Ribeirao Preto Vicinal Railway (532,302\$).

The Santos Dumont Railway was laid to the 23½-inch gauge, and is 17 miles long from the Mogyana main line to the banks of the Rio Pardo river. It runs through the famous "Amalia" coffee estate and the small town of Santa Rosa. The Mogyana Railway purchased the line on December 15, 1909.

The Vargem Grande Railway was taken over exactly one month later. It starts from the Mogyana's Lagao station, and is 13 miles long.

The Ribeirao Preto road was taken over on November 18, 1909. It is also a 23½-inch gauge, running to the Rio Pardo, some 24 miles away. The Mogyana intends pushing it beyond that river to Batataes, and so competing with the Sao Paulo & Minas line, the only one it has been unable or unwilling, so far, to take over.

On the west of its main line there were no small companies to buy up. But there is the important Paulista Railway to guard against, and as the Municipality—corresponding to the

British County—of Guatapara conceded a line to Ribeirao Preto, the Mogyana was almost forced to build one of its own, lest the other should some day fall into the hands of its enterprising neighbour.

A stadoal concession, therefore, granted the Mogyana a line from Ribeirao Preto to Guatapara and Jatahy, a port on the Rio Mogy Guassu, and from there to Sao Simao, an important town on the line of the Mogyana Railway. The length of the first section is 61 miles and that of the second only 14 miles. These concessions are dated November, 1909, and March, 1910.

The mileage of the Mogyana system is made up as follows:

	Length, Miles.	Sidings, Miles.	Total Miles.
Main Line:			
Campinas to Ribeirao Preto....	197.6	41.4	239.0
Ribeirao Preto to Jaguara.....	119.6	11.1	130.7
Catalao Extension.....	175.0	4.9	179.9
Amparo Branch, from Jaguara...	30.0	1.6	31.6
Socorro Branch, from Amparo...	8.7	0.4	9.1
Itapira Branch, from Mogy Mirim	31.2	1.0	32.2
Pinhal Branch, from Mogy Guassu	23.0	1.0	24.0
Mococa Branch, from Casa Branca	44.9	3.4	49.3
Guaxpe Branch, from Sao Jose...	19.1	1.0	20.1
Guaxpe Branch, from Minas Ex-			
tension.....	8.4	0.7	9.1
Sertaosinho Branch.....	20.9	2.6	23.5
S. Rita de Rio Grande Line.....	97.7	4.9	102.6
Caldas Branch.....	48.0	2.0	50.0
Serra Negra Branch (23½-inch			
gauge).....	25.0	1.9	27.5
	849.8	77.9	927.5



BRIDGE OVER THE RIO MOGY GUASSU

To these should be added the extensions due to recent purchases and to the railway's later policy. These are:

	Miles.
Santos Dumont Railway.....	17 bought.
Vargom Grande Railway.....	13 bought.
Rebeirao Preto Railway.....	24 and extension building.
Santos Extension Railway.....	162 building shortly.
Rebeirao Preto and Jatahy.....	61 building.
Jatahy to Sao Simao.....	14 building.
Caconde Branch.....	18 building.
Monte Bello, Guaxpe & S. Sebastiao	building for the So. of Minas Railway.

The Paulista Railway and the Mogyana Railway systems are about the same length; the returns are comparable, as they serve similar districts.

But it is not a good thing having split up the country into a number of zones converging towards Sao Paulo, and each belonging to separate companies. The country is bound to be drained fanwise, each company having no interest in building cross-

country routes, so that while the railway system has a very considerable mileage the development of the whole State is subsidiary upon that of the town of Sao Paulo and the harbour of Santos.

There has been a good deal of talk periodically about a general amalgamation or absorption of the several companies, which would be a boon were the Government of the State to keep sufficient control on the system to be able to prevent the objections attending upon railway monopoly. The Mogyana has been endeavouring to create such a monopoly in the east of Sao Paulo and west of Minas States, and has succeeded but partially. Whether the absorption of the Mogyana itself and, perhaps, its neighbours besides will prove beneficial, is almost entirely dependent on the contract that would sanction such an amalgamation.

(To be continued.)

THE IRON AND STEEL TRADE OUTLOOK

By T. Good

AMERICAN AND BRITISH COMPETITION FROM A BRITISH POINT OF VIEW

The following article, written at the close of the past year, reviews from a British viewpoint the possibilities which are involved in the competition of the American manufacturers of iron and steel products with the steel works of Great Britain, especially as regards the trade of the outer world, so to speak, the great market of the countries which do not manufacture sufficient, if at all, for their own use, the markets which have until now principally been supplied with British products. Bearing in mind the fact that the opinions here expressed are those of an English expert, this review of the situation will be found instructive and stimulating to manufacturers on both sides of the Atlantic.—THE EDITOR.

THE progress, position and prospects of the British iron and steel trades are well worth attention just now. On the one hand Germany is boldly challenging English supremacy in the export trade. On the other hand the American manufacturers have increased their productive capacity so largely—so far beyond the limits of their home demand—that if they choose to conduct a big dumping campaign in order to employ their mammoth furnaces and steel mills they can undertake practically the whole of the world's export trade, elbowing British, German and other competitors out of the race. Indeed, the situation is unique in the annals of industrialism, and it is time the facts were faced, for no country is so dependent upon a large and progressive export trade in iron products as Great Britain.

Next to agriculture, the world's most important productive industry is now that of iron and steel manufacture. In America, Germany and Britain, iron ranks next to agriculture. In number of persons employed, the iron group of trades in Great Britain surpassed the textile group for the first time at the 1901 census. While the textile group of industries employed 1,462,000 persons, most of whom were females, in 1901, the iron and kindred trade employed 1,475,000 workers, practically the whole of whom were men. Thus, from a wage, an employment, or any other standpoint, the British iron industry stands out above all other manufacturing industries.

And so it is in America and Germany. But the iron trade is of far more importance to England than it is to America or Germany. Britain depends far more upon imported raw materials than they do, and, therefore, depends far more upon exports of manufactures, of which those of iron are now the chief. But the Germans, less dependent upon iron exports, are very rapidly overtaking the British in this branch of trade; while the Americans, still less dependent upon such trade, have pushed their productive capacity so far in excess of their domestic requirements that they have at last a splendid opportunity of carrying out their oft-repeated threat to "annex the world's trade in steel." The international iron and steel trade situation was never so full of possibilities as at the close of 1910.

First, let us turn to the question of American competition, for that is regarded in some quarters as the most uncertain factor. In the last five calendar years British and American iron and steel exports have compared as follows:

	IRON AND STEEL EXPORTS FROM:	
	United Kingdom,	United States,
	Tons.	Tons.
1905.....	3,721,000	1,010,000
1906.....	4,682,000	1,325,000
1907.....	5,311,000	1,301,000
1908.....	4,233,000	964,000
1909.....	4,380,000	1,243,000

In the last ten years, for every dollar's worth of iron products exported by the United States Great Britain has exported a sovereign's worth. But is there going to be a change in this re-

spect? We are told that the American manufacturers are opening sales bureaus in the Argentine, Brazil and other countries; they have just recently sold large quantities of steel rails in Australia; and their agents are offering steel in English markets at attractive figures. There are whisperings of a big American dumping campaign. And if the American manufacturers are to find anything like full employment for their mills the campaign in foreign markets will indeed have to be a big one.

Consider! When for a period of about a year and a half following the financial panic of October, 1907, half the steel mills in America were shut down and no great dumping campaign conducted, we were told that the manufacturers, after working a couple of years at high pressure, welcomed the opportunity of overhauling their plants, relining their furnaces, scrapping old machinery, and getting ready for the great boom of 1900-10-11. Going a little further back, we find America's excuse for not indulging in a big export trade was that her steel manufacturers were hard pressed to cope with home demands, without troubling much about foreign trade. Although from time to time during the closing years of the nineteenth century and the earliest years of the present one United States steel makers boasted of their low productive costs, and threatened to "annex the world's trade," Britain has still retained first place in the world's neutral markets. But we were told that we only held our position on sufferance. No less an authority than Mr. Carnegie told us, only two years ago, that we had reached the apex of our manufacturing powers, that our raw material supplies were rapidly giving out, and that America could easily beat us in cheap steel production.

However, when trade was good and the Americans did not beat us in the export business we were told that it was because they were too busy supplying their domestic market. When the trade in their domestic market was

suddenly cut down by one half, in October, 1907, and long remained so, and still they made no effort to secure the lion's share of the export trade, the explanation was, as just mentioned, that they were glad of a chance to put their house in order for the next great boom in their own country. Not only were old plants got in order for the good time coming, but new extensions were made on a most lavish scale. New furnaces and mills sprung up like mushrooms in the United States, for it was said that the next boom would far surpass anything ever experienced in the world's history. Besides, even if the American home market could not absorb all the products of the mills, there was a world's export trade in iron and steel approaching 12,000,000 tons a year, most of which was in the hands of British and German traders, but which could easily be taken by the Americans when required.

Well, the end of 1910 has come, but the anticipated American boom has not arrived. It is nowhere in sight. But the new steel mills, such as the mammoth Gary, have been built. The home demand shows no sign of fully employing them. With a blast furnace capacity equal to the production of at least 33,000,000 tons of pig-iron a year, there is no visible sign of a domestic demand in the United States good enough for more than 25,000,000 tons annually. With a steel works capacity of 30,000,000 tons a year there is no trade in sight within the geographical limits of the country for more than 23,000,000 tons annually. With a steel rail mill capacity of 7,000,000 tons, there is not a shadow of a sign of a demand for a rail beyond 3,000,000 tons a year. The spectacle is unprecedented. Productive capacity has been pushed millions and millions of tons beyond consumptive requirements. Iron and steel plants—not obsolete, but costly, new, and up-to-date concerns—representing tens of millions of capital standing idle in America. The directors of the Steel Corporation admit that the plants of that concern only worked up to 75 per

cent. of capacity in 1909. For 1910 the record will be still lower, and the bookings are now barely equal to 50 per cent. of capacity. Meanwhile, still more new furnaces and mills are being erected, and when present projects are completed the country's aggregate capacity, in terms of pig-iron, will be 38,000,000 tons a year! This will be, to all appearances, some 12,000,000 or 13,000,000 tons in excess of home requirements.

But there remains the export trade. Are the United States manufacturers about to make a bold bid for export trade in order fully to employ their plants? Some people think so, and seize upon every offer of American iron and steel in foreign markets as evidence of such an intention. If the Americans are really disposed to find full employment by means of pushing exports, then the whole face of the international iron and steel trade is about to be changed, for there are very nearly enough idle plants in the United States to do the whole of the world's export trade. Let it be clearly understood that the trade is available—it is there for the lowest bidder to claim—and the American competitors have the materials and the plants to do it. The only debatable point is whether or not they can produce cheaply enough to enable them to claim the trade and employ their plants. Of course, we may be told that there are various international agreements in the steel trade under which Britain takes the largest, Germany the second largest, and America the third (a bad third) largest share of exports, regardless of productive costs. But all such agreements are terminable, and we may be sure that if the rivals feel themselves able to produce at a low cost they will not allow any agreement to stand permanently in the way of their interests, especially now that they have so many huge and costly plants idle. Indeed, some of these international agreements are already at the breaking point. To-day the international steel rail syndicate, the most powerful of its class in recent years, is tottering to its very

foundations. It may collapse at any moment, and then there will be a scramble for the business, in which the strongest competitor—in other words, the cheapest producer—will get the most trade. In a word, the international steel trade may be in the melting pot at any time, and the whole question of future competition rests upon the problem of productive costs.

In which country, then, are the costs of production the lowest—Britain or America? Mr. Carnegie emphatically declares America! But is Mr. Carnegie correct? If he is, then the outlook for Great Britain is black indeed. Let us see. Let us try to get down to the bed-rock facts.

Cheap steel production depends upon cheap pig-iron. The cost of pig-iron is, therefore, the cardinal point in the problem. To get at the exact cost of iron production either in Britain or America at the moment is scarcely possible, but we can get near enough the mark of accuracy for all practical purposes. And here it is necessary to take a glance backward. In the five years 1890-4 the average costs of producing pig-iron in America, according to the United States Industrial Commission, were as follows, in English equivalents:

	Per Ton.	
	s.	d.
1890.....	62	0
1891.....	51	0
1892.....	53	0
1893.....	45	6
1894.....	34	6

Later in the nineties, two eminent authorities, Messrs. Jeremiah and A. P. Head, arrived at the following estimates of the prime costs of a ton of steel-making pig-iron, Bessemer or hematite, at Pittsburgh and Middlesbrough:

COST OF PIG IRON PER TON AT
PITTSBURGH

	£	s.	d.
1.66 tons of ore at 12s. 8d.....	1	1	1
16 cwt. of coke at 7s.....	0	5	7
12 cwt. of limestone at 3s.....	0	1	9½
Labour	0	2	0
Repairs	0	1	0
Other items	0	1	0
	1	12	5½

COST OF PIG IRON PER TON AT
MIDDLESBROUGH

	£	s.	d.
1.95 tons of ore at 15s. 2d.....	1	9	7
20.5 cwt. of coke at 15s. 6d.....	0	15	10½
9 cwt. of limestone at 3s. 9d.....	0	1	8½
Labour	0	3	0
Repairs	0	1	0
Other items	0	1	0
	2	12	2

The American manufacturers then claimed that they would soon be making iron at 30s. a ton and all iron products at correspondingly low figures. Their leading men said eleven years ago that they could produce rails 29s. per ton cheaper than we could, and that they would put down new plants and dominate the world's steel trade. But see what has happened since then. Productive costs in mining, assembling and manufacturing have gone up more rapidly in the American iron and steel trades than in any important group of industries anywhere. Meanwhile, British costs have been pulled down somewhat. If we did not succumb to American competition ten or a dozen years ago we are not likely to do so now.

Sixteen years ago the cost of producing American iron was 34s. 6d. per ton. Twelve years ago it was 32. 5½d. What is the cost to-day? We cannot say exactly, but less than two years ago the United States Government was supplied with documentary evidence that the cost of a ton of pig-iron, at the best blast furnaces in Pennsylvania, excluding every cent of profit all along the line, from mining the ore and coal and making the coke to stacking the pig, was 56s. 6½d., while the Bureau of Corporations gave the country's average as 58s. 4½d. Contrast this with the 32s. 5½d. of ten years previously (now twelve years) and we get an increase of 25s. 11d. per ton in this prime essential of American steel-making—pig-iron. In the same ten years the cost of producing a ton of standard rails went up from \$19.85 to \$26.35—the result of deeper and more difficult coal and ore mining, higher rents and royalties, greater transit costs, and so forth.

We are by no means disposed to ignore the possibilities of American competition, but we do insist that those possibilities are too frequently magnified. People seem to forget that in the United States the iron ore deposits are mostly a thousand miles from the coal fields, and that the manufacturing plants are almost the same distance from seaboard—a big geographical handicap in competition with a country like Britain, where we have raw material supplies, furnaces, mills, and shipping ports all practically side by side. Besides, the American steel industry is cruelly overburdened with capital obligations. The simple truth is that the United States iron and steel trade has to labour under such great natural and geographical disadvantages, and under such a load of capital charges, that it is by no means such a formidable competitor in foreign markets as is commonly supposed. In the last ten years American smelters have had an average of 15s. per ton more for their iron than British smelters have had for theirs, and the steel mills have had correspondingly more for most of their products, yet our rivals have been in greater financial difficulties than we have. The present offers of cheap iron and steel from the United States are more likely the outcome of financial pressure than evidence of real competitive strength. In our opinion America stands no chance of beating either Britain or Germany in the export trade, save in perhaps specialties. We consider that the export trade offers absolutely no prospect of full employment for America's steel plants, simply because her productive costs are too high to permit her to indulge largely in such trade. In building so many new furnaces and steel mills our American rivals have overreached themselves.

Britain's real rival in the export trade is Germany, and the progress of that country and the present developments there merit strict attention.

Here are the German export figures, compared with British, since 1900:

IRON AND STEEL EXPORTS FROM:

	United Kingdom, Tons.	Germany, Metric Tons.
1900.....	3,213,000	838,000
1901.....	2,617,000	1,410,000
1902.....	3,241,000	2,126,000
1903.....	3,209,000	2,199,000
1904.....	3,366,000	2,770,000
1905.....	3,721,000	3,349,000
1906.....	4,682,000	3,666,000
1907.....	5,311,000	3,455,000
1908.....	4,233,000	3,732,000
1909.....	4,380,000	4,044,000
1910 (first 8 mos.)	3,163,000	3,171,000

These figures provide ample food for thought. British supremacy is indeed threatened. In some respects it is already gone. Germany is now making pig-iron at the rate of about 14,000,000 tons a year, against England's 10,000,000 tons. She is making steel at the rate of 12,000,000 tons a year, against our 7,000,000 tons. She is employing 2,000,000 workers in her iron and steel group of industries, against our 1,500,000. And now she has just about drawn level with us even in exportation. In ten years Germany's exports have increased by nearly 400 per cent. What are we to look forward to in the next decade? As already pointed out, a big export trade is far more essential to the British than to the Germans, inasmuch as we produce far less food than our contemporaries. But what are we doing, compared with the Germans, to maintain a big and progressive export trade? What are we doing to keep ahead of the Germans? And why, indeed, should Germany beat us?

Such are the natural, geographical, and economic conditions in the German iron trade that it is quite impossible for our rivals to assemble raw materials at smelters, or make iron, or produce steel, quality for quality, or put the finished product on board ship, so cheaply as we can. Long distances separate German's iron ore mines from her coal pits, and her manufacturing plants from seaports. In this country we labour under no such disadvantages. By virtue of our superior

natural resources and better geographical situation, not to mention the inherent skill of our labour, we occupy a much stronger competitive position than the Germans. Yet the Germans are going ahead rapidly while we are doing little more than mark time. Nor is the reason far to seek. The Germans possess and use the powers of combination, co-operation, organization. We possess the materials, the men, and the money, coupled with natural favours; but we lack efficient organization, and if we cling much longer to our ancient methods and antiquated notions we shall be elbowed out of the race altogether. Germany owes her position and progress to superior organization, and the lesson for use is plain and unmistakable. The Germans, their home market protected against dumping, their manufacturers closely organized and pushing their foreign trade by means of co-operative export bounties, are enabled to go on investing more and more capital in their home industries, building more and more mills, employing more and more labour in their own country, while we, our home market unprotected and our manufacturers badly organized, are investing little fresh capital in our industries, doing little to increase our trade, and sending most of our money abroad for investment and the best of our workmen along with it. In the recent past we have been relegated from the first to the third position as an iron and steel country in point of actual national production, when we ought easily to have retained second position; and now, this year, with our supremacy even in exports threatened, we have arrived at a critical stage in our commercial career. It is time to face the facts. And it is time to mend our ways. Once let our commercial supremacy go, and nothing can prevent economic decay.

THE NEW SHIPPING CREED

By Walter M. Oestreicher

(Concluded from December, 1910.)

In our December issue we gave some interesting information concerning the developments which are being made at the port of New York in connection with the work of the Bush Terminal Company, providing facilities for the combination of a great shipping terminal and of the manufacturing industries associated with it. The present instalment concludes this description of what is believed by many to be one of the most important steps yet made toward the solution of the problem of the relief of municipal congestion, by facilitating the actual business operations, while at the same time removing from the streets the bulk of useless and costly hauling of merchandise.—THE EDITOR.

The Bush plant is located in what is called South Brooklyn. It is a healthy section, its residential portion being set on a ridge that slopes gently toward the waterfront, past which flows the government channel—one of the most quiet and favored arms of New York Bay. Like the fingers of a giant's outspread hands, the Bush piers extend 1,400 feet into the water, and along their sides dock steamers, big and little, laden with the ocean-borne commerce of the five continents. First avenue forms the parallel line with the bulkheads, and there begins a city of warehouses, ranging from one to six-story structures. Winding in and out through the cross streets run the tracks of the Bush Terminal Railway, a private line that touches every nook and corner of the plant and terminates in the Union Freight Depot. There, strings of cars of every line that carries freight from and into New York City stand in readiness.

Spurs of these tracks shooting from the warehouse district form the most important arteries of the entire system. They lead into that section of the territory where the loft buildings rear their immense bulks into the air, six stories each, and each containing more than 300,000 square feet of floor space. Between these buildings run the Bush tracks. Let us suppose that tenant "A" desires to send a bill of goods to some point outside of New York, while tenant "B" has been notified that a consign-

ment of raw material has arrived and is now held at the Union Freight Depot for further disposition. Tenant "A," in the past, had a loft in a crowded wholesale section. Whenever he had a shipment ready he called for his trucks and had them loaded, after which they proceeded upon their tortuous way to some far-off shipping terminal, there to be unloaded and reloaded into a freight car. Since he has become a member of the Bush colony his operations have grown less complicated. He merely telephones the superintendent of the particular loft building in which he is located that the goods are on the elevator ready for shipment. If he has labeled them properly, his responsibility is at an end. The Bush employees take the loaded elevator to one of the platforms at the elevator gates below and in a few minutes a Bush locomotive has shunted a freight car of the particular line desired into the spot. The process being over, the locomotive runs the shipment into the Union Depot, whence it starts, over one of the floatbridges, upon its way to its destination in the original car. No time has been lost, and the congested city streets have been avoided. The size of the shipment alone determines the amount of money saved.

And now let us see how tenant "B" has proceeded in the meantime. Having been offered his raw material at an exceptionally low price, he had bought a larger stock than he really



A BIRD'S-EYE VIEW OF THE BUSH PIERS.

needed. Formerly, while he was still in a crowded wholesale district, he was unable to avail himself of such opportunities, because his loft was, naturally, not adapted for storage purposes, and cartage to a warehouse would have eaten up the margin of the lower purchase price. Since his arrival in South Brooklyn, however, the situation has changed materially. A telephone message notifies the warehouse superintendent of the Bush Terminal Company that half of the consignment is to be held in storage.

Accordingly, the car is sent to one of the warehouses, where part of its contents is unloaded. With the rest it proceeds to the tenant's loft building and one of the elevators discharges the material at his very door. Then after the material has been turned into the finished product, "B," in shipping it, proceeds exactly as "A" did.

More than a hundred manufacturers and wholesalers are now among the Bush tenants. They represent every conceivable industry, from



A FURNITURE MANUFACTURER'S LOFT IN A BUSH BUILDING



A STREET BETWEEN THE LOFT BUILDINGS

wholesale garment workers to importers of Oriental curios, from manufacturers of fruit juices to representatives of New England's vast cot-

ton mills. One of the latter reports saving \$13,000 in one year; another, a furniture manufacturer, whose receipts of steel, cotton and lumber



A TYPICAL BUSH LOFT (DETMER WOOLEN COMPANY)



A FREIGHT TRAIN AND ELECTRIC LOCOMOTIVE BACKING UP AT THE DOOR OF A BUSH LOFT BUILDING

number many carloads a month and whose shipments are proportionately large, expects to economize to the amount of \$25,000 annually, in addition to extending his factory space without extra cost. One of the garment manufacturers used to pay \$1 insurance and now pays 22 cents. This, then, is the practical side of

the new shipping method, which, on the part of the shipper, requires only that he be sensible enough to locate near the point of distribution. If he accepts the idea, he simply follows the example of the economical workman who moves into a neighborhood near his work-bench in order to save time and car fare.

RAILWAY MOTIVE POWER PROBLEMS

By F. H. Clark

In view of the present discussion of the possibilities of largely reducing the expenses of railway operations by the adoption of modern scientific methods, the following address, delivered recently before the College of Engineering of the University of Illinois by Mr. F. H. Clark, general superintendent of motive power of the Chicago, Burlington & Quincy Railroad, is of especial interest.—THE EDITOR.

SOME of us used to think during my time in the university that nothing but engineering mattered very much to us, and that there was very little use in our paying serious attention to other than the engineering branches of our college courses. Probably you are better advised and you may be interested in hearing something of the various problems, some of which have little or nothing to do with engineering, which claim the attention of railway motive-power men.

I shall have to speak somewhat generally, because of the fact that the organization of various railroads differs considerably, and the problems frequently met in the motive-power department of one road may be unimportant on another. I recently had an interesting conversation with a gentleman who for about five years was in charge of the motive-power department of a short but important railroad in the tropics. I found that in addition to the work that usually falls to the motive-power department he had a good deal to do with sanitary problems, such as hospital equipment, the building and operation of ice-machine plants and other work of a mechanical nature incident to life in the tropics. Such problems are seldom met with in temperate climates by railway motive-power men, but, on the other hand, we have to maintain, and occasionally use, snow plows and to meet other problems, as of heating and ventilation, which gave him no concern.

The functions of the department, broadly speaking, are of design, construction, maintenance and operation.

The engineering phases are generally questions of design, though you will find traces of engineering throughout the entire list. Briefly speaking, the work of the motive-power department consists of the design of freight and passenger cars, locomotives and shops, their construction, which in the case of cars and locomotives is mostly done in the shops of contractors, and the maintenance of cars, locomotives and other equipment, which is usually done in the shops and roundhouses of the railroad company. The extent to which the motive-power department is involved in the operation of cars and locomotives varies on different roads, depending largely upon their organization.

The designing of cars and locomotives may be done in the offices of the railroad, or in those of the builder. Some railroads go very much into details in matters of design, while others depend largely, or almost entirely, upon the builders for their design. The railroad usually has a pretty definite idea, however, as to the character of the equipment and construction wanted, and the builders are at least given limitations, either of weight, capacity, or price, to which they work. Like other engineering work, there are certain standards and practices generally observed, as in the case of car axles, freight car wheels, brake shoes, air brakes, locomotive injectors and similar equipment, so that it is not necessary for the designer to work up all the details, but is at liberty to use and in fact is required to depend upon the work of others to a considerable extent

in getting out his plans. I once knew a structural steel draftsman who invariably refused to use a formula or a table of weights, moments of inertia or logarithms which he had not personally checked. He was a fine mathematician and thoroughly capable of deducing formulæ and logarithmic tables, but he consumed so much time in unnecessary computations that he was not of very much use as a designer. We usually find it desirable to depend upon the work of others to a certain extent, and the most of us are willing to accept well-authenticated data at their face value for at least once. Our experience teaches us that a six-wheel passenger truck with journals of a certain size, and with proper lubrication, can be depended upon to carry a certain weight under normal conditions; that a certain size of locomotive injector is capable of supplying water to a boiler of a certain size and intended for some particular service, but that under different conditions a larger or smaller injector may be used to advantage; that with one kind of coal a locomotive intended to haul a given train may require a grate area of 80 to 100 square feet, while with a different kind of coal a much less area is ample. It would seem, therefore, that railway engineering design was very largely a matter of experience, but the fundamental principles can certainly be much more easily acquired in an institution like this than in any other way.

As for the question of shop design, it does not very often happen that we have an opportunity to lay out a shop as we would like to have it; there are usually limitations with respect to property lines, topography, finances or the utilization of existing buildings that have to be taken into account. Perhaps you have all had something to do with the planning of a house, or other building, and realize the difficulty of getting enough rooms of the size wanted, all of which will have a south exposure, with an amount of funds on which some other fellow was able to build a house only about one-half as

big as the one you want. Having designed and built the house you perhaps found that it cost about 50 per cent. more than you wanted to spend, and had no suitable places for beds and other furniture. The same class of questions arise in the designing of shops and the selection and installation of equipment.

The purchase of material and equipment on railroads, and in other large organizations, is usually left to a purchasing agent, who consults more or less freely with the officers of the motive-power department and other departments for whom he buys, and as a general thing this material, or equipment, is bought to the specifications of the department using it, and is inspected by the same department. In order to meet this need for inspection, a test department is maintained on most of the larger railroads, and the material is either inspected at the mills or at the laboratory of the railroad, the nature and thoroughness of the inspection depending very largely on the amount and kind of material under consideration. This inspection is extended to material used in the construction of new equipment, and the equipment itself is usually inspected during construction by men taken from among the workmen of the railroad and especially detailed for the purpose, boiler work being inspected by a competent boilermaker, machine work by a machinist, the steel work of a car by a man familiar with such work, the air brakes by a man familiar with air-brake work, and the painting by a practical painter. The inspection and testing of material and equipment are frequently performed by the employees of the various bureaus organized for that purpose, and who maintain a sufficient force of men of various qualifications to cover the work in hand. A railroad will frequently furnish its own inspectors for a part of such work and depend upon the inspection bureaus for the remainder.

Assuming that our equipment has been designed, purchased and delivered, the questions of operation and

maintenance begin to arise. Our locomotives are put into service and from the start require a considerable amount of attention at terminals. In order to provide the necessary attention, engine houses or roundhouses are furnished where the engines are provided with coal, water and sand, and given such repairs as their condition requires. These day-to-day repairs, or running repairs, as they are generally called, are performed by machinists, blacksmiths, boilermakers, hostlers, oilers and various others. An engineer bringing in an engine is usually required to fill out what is commonly called a work report, on which he indicates the repairs or other attention needed. On arrival at the engine house inspectors go over the engine, tightening up nuts and doing other work which can be quickly and easily done by means of a hammer or wrench, and making note of any work that may have been overlooked by the engineer. The roundhouse foreman, or his assistant, takes these reports, assigns the work to the various men interested and has the engine prepared for another trip. The boiler may need washing out or a change of water, the flues may need calking or rolling, the driving bearings or the engine truck or tender truck bearings may need repacking or oiling, or repairs may be necessary. This work may require two or three hours, or as many days, and thus the engine is kept in service until its condition becomes such as to require general repairs. These are usually made in a shop where the engine is held from a week to a month, or possibly longer, and where tires may be turned or renewed, axles and crank-pins trued up or replaced, cylinders bored, bushed or renewed, frames or other parts repaired, boiler or fire-box sheets renewed, flues removed and reset and various other work done, after which the engine is painted, and after breaking in is returned to service.

The cost of locomotive repairs varies widely, depending upon the age and general condition of the power, as

well as the size of the equipment and service in which it has been used. It usually falls between 3 cents and 15 cents per mile run, with an average perhaps of 6 cents or 7 cents a mile, and as a general thing the cost of repairs is about equally divided between roundhouse or running repairs and shop or general repairs.

It is quite possible that your attention has never been specifically called to the importance to the railroad of their round-house or engine-house facilities, though you all may have had opportunities to visit railroad repair shops and have been interested and impressed with the work done. There are about 60,000 locomotives in the United States and their cost of maintenance is approximately \$2,500 each. About one-half of this work, amounting to \$75,000,000, is done in the roundhouse. In addition to this running repair work the roundhouse organization is required to perform such service work as is necessary, including the movement of engines, the washing of boilers and tanks, the cleaning of flues, firing up, and coal-ing, sanding and watering, etc. The cost of this service varies between wide limits, and averages something over \$1.50 per engine, or approximately \$500 a year for each engine owned. This adds about \$30,000,000 to the amount expended in roundhouses and makes a total of \$105,000,000.

Assuming the cost of repairs to locomotives to be \$150,000,000 a year, the cost of repairs to freight cars about \$125,000,000 a year, and the cost of repairs to passenger cars about \$50,000,000 a year, makes a total of \$325,000,000 a year expended by railroads for the repairs of locomotives, and passenger and freight cars. Of this amount \$75,000,000, or 23 per cent, is spent for roundhouse repairs, with an additional \$30,000,000 for service.

The facilities necessary to promptly and economically handle this equipment are, of course, a matter of much

importance to the railroads and involves a good many engineering problems in the laying out and installation of coal and sanding stations, wash-out apparatus, power plants and other facilities.

The repairs to passenger equipment are handled in somewhat the same manner as locomotive repairs, the minor or running repairs being made at terminals, and heavy or general repairs at shops where facilities are provided for repairing or renewing worn, decayed or broken parts, and for painting, varnishing and doing other work necessary to preserve a good appearance. The terminal repairs consist very largely of washing, dusting and cleaning, and the renewal of brake shoes, journal bearings, wheels, axles and other parts subject to wear.

Freight car repairs are handled similarly, the light or running repairs, such as the renewal of brake shoes, journal bearings and air-brake hose, being performed at terminals, or intermediate points if necessary, and the heavy repairs at shop points, which are usually distributed over the road in such a way as to make it possible to repair cars conveniently without any considerable amount of light mileage in order to get them to a shop.

Freight cars, as you may know, are interchangeable between the various railroads of the country, and I suppose that if we were to go to the nearest large freight yard we would find cars belonging to the railroads of all parts of the country. On some railroads you will find that 75 per cent. or more of the cars in service are foreign cars, or cars owned by other railroads, while on other roads you will find not over 10 per cent. of foreign cars. In order to facilitate the movement of freight cars, and to make the best possible use of them, the railroads agree not only to interchange their equipment under mutually accepted rules, but to make repairs to the freight equipment of one another, the charge and credits involved being agreed upon through

the Master Car Builders' Association.

One of the present-day problems, as you may be aware, has to do with the relations between employer and employees. It is not altogether a question of wages, but largely a question of working conditions and arrangements. It is unnecessary to go into details, or to make any suggestions other than to point out to you the importance of an understanding of human nature. This has been the basis of a great many successes not only in the handling of labor, but in salesmanship, politics and, in fact, any line of work in which you have to deal with and get along with other men. Most men in high places in railway or other corporations are good executives. They may incidentally be engineers, but they hold their places not alone because they are good engineers, but because they possess the faculty of successfully planning and directing the work of others. A man's success depends not on what he alone can do, but upon his ability to interest others in his plans and ideas, and to get them to co-operate with him in carrying them out.

Having thus briefly indicated to you the nature of the problems of the department some further remarks may be in order as to the considerations necessarily involved in their solution. It is the business of the railroads to provide means of transportation, both for passenger and freight, and to make their service as efficient and attractive as possible. The management of a railroad is necessarily specialized or divided into several departments, all working with the same end in view. They must therefore work in harmony and with due consideration for the conditions and requirements of the other departments. This makes it necessary for the motive-power-department to keep in sight some of the problems of the transportation and traffic departments; it means that our freight locomotives shall be so designed that they can make their trips over the road in reasonable

time and haul trains heavy enough to make it possible to do business at a profit; that our passenger engines must be so constructed that they can comfortably haul a reasonable number of passenger cars and maintain a schedule usually fixed by competitive conditions. The freight cars must be designed with reference to the service for which they are intended and the convenience of the shippers. In the design of a passenger car we usually have instructions to provide something better or finer than the cars of our competitors.

We find it desirable in the purchase of material to keep in mind the manufacturers located on our own lines, and other things, such as price, quality and delivery, being equal, to give them the preference. The difficulty of this problem is to determine when other things *are* equal. A similar difficulty arises when in the purchase of new cars or locomotives we are called upon to make a selection of specialties, and we have to determine,

for instance, whether we shall continue the use of a certain device which we know is good or try one which looks good and is offered at a lower price.

One of the problems that is always with us is that of making reductions in the cost of doing work. We cannot make such reductions by reducing the pay of the workmen, but may be able to do so by changes in methods of doing the work, which may involve the purchase of new machinery. Will it pay to do it? Doubts are continually arising as to the advisability of making heavy repairs to old tools, old cars and old locomotives, and in continuing them in service or of destroying them.

I think I have said enough regarding our problems and hope that what has been said will not lead you to think that the work is disagreeable. The most of us, on the contrary, find it exceedingly interesting, because, perhaps, of the variety of the problems involved.

BOOK NEWS

Plumbing

Standard Practical Plumbing. By R. M. Starbuck. Size, 6½ by 9½ inches. Pp. 450. Illustrated. Price, \$3.00. New York: The Norman W. Henley Publishing Company.

A practical book, treating of the actual mechanical operations of plumbing; this is also a treatise upon an important department of sanitary engineering too often neglected in the more scientific works in that field. Apart from the detailed instruction in the actual work of the plumber, the work contains much useful information for the owner and householder as to principles of venting, drainage, piping and the planning of satisfactory and sanitary systems for buildings of various kinds. These cover not only residences and dwellings, but also schools, hotels, factories, etc.

In addition to plumbing for drainage and the removal of wastes, the subject of hot water supply, both for residences and apartment houses, is discussed, this being not the least useful portion of the book. The illustrations are excellent working drawings, and not the ordinary catalogue cuts.

Lake Navigation

Our Inland Seas; Their Shipping and Commerce for Three Centuries. By James Cooke Mills. Size, 5½ by 8½ inches. Pp. xvi., 380. Illustrated. Price, \$1.75 net. Chicago: A. C. McClurg & Co.

At the present time, when so much is being said and written about the necessity for the development of the merchant marine of the United States, such a book as this, telling what has been accomplished and what is being done now on the Great Lakes, is especially timely.

Mr. Mills has written an excellent history of shipping on the Lakes, and of necessity this involves much of the history of the development of

the Northwestern States. From the early days of the Indian canoe and dugout, through the growth of the sailing vessel and the wooden steamboat down to the steel ore-carrier and the palatial passenger steamer, the story of three centuries of progress is well told. The profusion of illustrations, many of them reproduced from rare originals, adds to the interest of the narrative, and the whole forms a section of commercial history and national development which demands the attention of the general reader, as well as of the engineer and the economist.

Examined from the economic point of view, the extent of the commerce of the Great Lakes is a matter of surprise even to those who have some general idea of the subject.

Thus, in a navigation season of about two hundred and forty days the commerce of the Great Lakes now exceeds eighty-five million tons. In a single season of navigation in the waterway called the Detroit river the number of passages reported was nearly thirty-eight thousand—about *ten times* more than was recorded for the Suez Canal, while the aggregate of the cargoes exceeded *sixty-seven million, two hundred and fifty thousand tons*, an amount far greater than that borne by all the ships, British or foreign, entering the ports of Great Britain in an entire year. It also exceeded the total merchandise tonnage entering the harbours of New York, Boston, Philadelphia, Baltimore, Charleston and Savannah combined.

About 90 per cent. of the tonnage on the Lakes is composed of iron ore, coal, grain and flour, and of lumber. Iron ore forms about one-half of this, reaching, in 1909, forty-two million tons, of which about twenty-

five million tons was for the United States Steel Corporation. During the same year there were more than twenty-one million tons of coal transported, thus forming largely return cargo for the ore and grain ships. Other important shipments included salt, copper, stone, cement and sand. The tonnage of Cleveland, Ohio, has exceeded that of Liverpool, and the Cleveland district is second only to the Clyde as a shipbuilding point.

These facts, and the conditions which accompany them, are well worthy of close study at the present time, and in Mr. Mills' valuable book they are set forth in a manner both interesting and instructive.

Mine Rescue Stations

The location of the three mine rescue stations provided for under a recently enacted law of Illinois has been decided on; one will be at Benton, in the Southern Illinois coal fields; one at Springfield, in the central, and the third at La Salle, in the northern coal fields.

Two men will be appointed for each station, one as general manager and the other as superintendent. Eight men have recently passed preliminary examinations for these positions, and have been in training for this work at the Government rescue station at the University of Illinois. The training comprises practice in the use of rescue apparatus in a smoke chamber and instruction in the proper use and care of rescue apparatus. These men have had unexpected additional practice in a mine fire which occurred during their stay at the University of Illinois. During this period of training the members of the faculty of the School of Mines and of the Department of Geology supplemented the practice work by lectures on "First Aid Work," "Mine Gases," "Coal Dust," "Safety Lamps," and "The Geology of Coal."

"Suppression of Competition"

At the present time the normal transactions of business are forbidden by highly penal statutes. Business men now enjoy liberty only according as the prosecuting authorities indulge them in the open breach of the law. Plainly, our legislation respecting large business must be confessed to be a failure. The causes of this failure are simple. The legislation upon which we heretofore have relied has been directed toward two absolutely inconsistent purposes: the furtherance of free competition and, at the same time, the prohibition of the very agencies and organizations in which free competition most normally expresses itself. The Sherman Anti-Trust Act and the anti-trust laws of most of the States are striking illustrations of this hopeless contradiction of purpose. Everyone agrees that these laws were enacted to further free competition. Everyone knows that no business man would undertake the strife of competition without the assurance that he may enjoy the price if he wins out. In order to preserve healthy competition, the legitimate growth and lawful extension of the business of the successful trader must be protected.—*Gilbert H. Montague, in "Business Enterprise and the Law," in the North American Review.*

Books Received

Hydraulic Elevators. By William Baxter, Jr. New York: Mc-Graw-Hill Book Co.

Dynamo-Electric Machinery. By Samuel Sheldon and Erich Hausmann. New York: D. Van Nostrand Co.

The Construction and Working of Internal-Combustion Engines. By R. E. Mathot. New York: D. Van Nostrand Co.

High-Speed Steel. By O. M. Becker. New York: D. Van Nostrand Co.

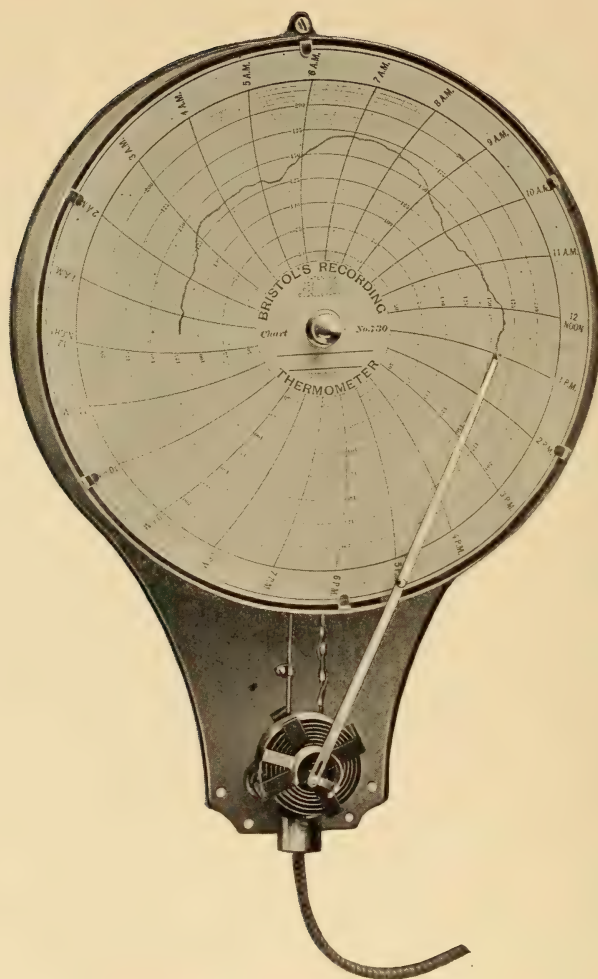


FIG. 1.—THE BRISTOL GAS-FILLED RECORDING THERMOMETER

Bristol's Compensated Gas-Filled Recording Thermometers

During the last fifteen years Bristol recording thermometers have been constructed in various different forms, depending for their operation on the expansion of a liquid, the expansion of the vapor of a liquid or the expansion of a gas. These thermometers have been used very extensively for ranges of temperature up to 800 degrees F., but the models equipped with flexible connecting tubes between the sensitive bulb and recording instrument and depending for their operation on the expansion of a vapor or a gas have not until

recently been adapted for recording the lower ranges of temperature.

A new compensated gas-filled Bristol recording thermometer has recently been developed for recording the lower ranges of temperatures, such as atmospheric temperatures, temperatures of water, temperatures of brine in refrigerating systems, etc., and found satisfactory in numerous tests. These thermometers are equipped with a patented compensating device which automatically corrects for changes of temperature at the recording instrument.

Bristol's gas-filled Class III recording thermometers are equipped

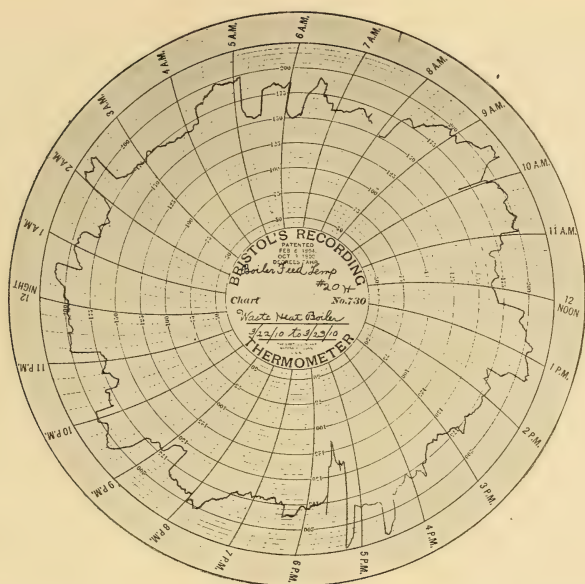


FIG. 2.—FEED-PUMP TEMPERATURE RECORD MADE BY BRISTOL RECORDING THERMOMETER

with sensitive bulb and flexible capillary connecting tube and a patented pressure tube, as shown in Fig. 1, the sensitive bulb and flexible connecting tube and spiral pressure tube all being filled with an inert gas un-

der pressure. Changes of temperature at the sensitive bulb cause corresponding changes in the pressure of the confined gas and these changes in pressure are measured and recorded by the recording instrument, the

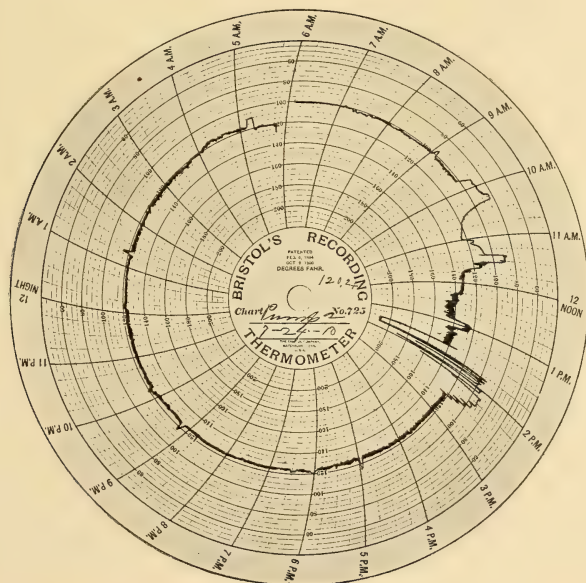


FIG. 3.—PUMP RECORD FROM BRISTOL THERMOMETER

interior construction of which is shown in Fig. 1. The sensitive bulb is usually about 10 inches long and $\frac{3}{4}$ inch in diameter, and the volume of gas contained in this sensitive bulb is very large in proportion to the volume of gas contained in the fine capillary connecting tube between the sensitive bulb and the recording instrument, this making the error due to change of temperature along the connecting tube negligible.

Scientists have long recognized the fact that an air or gas thermometer is the ideal type of apparatus for measuring low temperatures, provided that the air thermometer can be manipulated in the laboratory, where it is possible to make various corrections. The very important new feature of Bristol compensated gas-filled recording thermometer is the patented compensating attachment for the spiral pressure tube, shown in Fig. 1, since a thermometer equipped with this compensator gives the same readings or record when the temperature at the recording instrument changes as it would if the temperature at the recording instrument remained constant. The need for such a compensator can be illustrated by the application of a recording thermometer for recording temperature of brine in a refrigerating system. The temperature of the atmosphere at the point where the recording instrument was installed might change although the temperature of the brine at the point where the sensitive bulb was installed remained constant, and a recording thermometer for brine temperature should, of course, be so constructed that it would be affected only by changes at the sensitive bulb.

The Bristol Company have completed their new building, to be used exclusively for the manufacture of belt fasteners, and which will constitute one of the most up-to-date plants ever constructed for such purposes. A description of the plant will be given in a later number.

Electric Motors in a Vocational School

THE old idea of a manual training school was one literally expressed by the name—a place where the art of working with the hands alone was taught. To-day the vocational school, as it is called, gives instruction not only in the use of hand tools, but also with the aid of standard machines, such as the workman has to use in the regular workshop. In the shop of the Vocational School for Boys, in New York City, this instruction is further extended by the addition of individual electric motors to drive these machines.

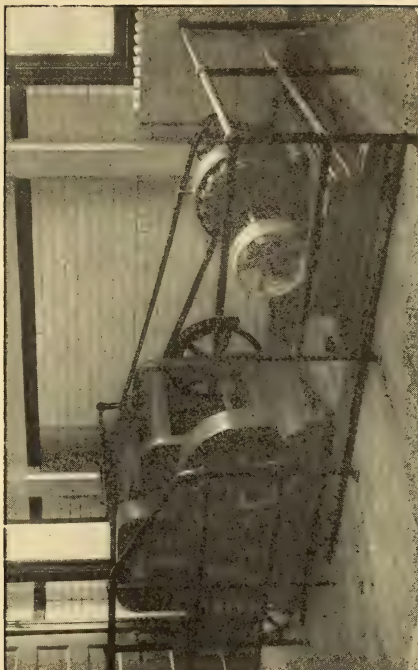
The extent to which this has been done is well shown in the accompanying illustrations, which show a variety of woodworking tools driven by Westinghouse electric motors and arranged for the work of the school in a most convenient manner. The advantages of independent electric driving are fully secured in this installation, and, in addition, the arrangement permits any one of the machines to be used independently of the others, either in regular service or for use in extra work outside of the usual hours of instruction.

The Vocational School is intended to enable boys to secure a practical education which will prepare them for industrial careers as distinguished from office work. The pupils are given opportunity to learn the elements of various trades and to study practical free-hand, architectural and mechanical drawing, and at the same time to continue with a general education. The course covers one or two years, and is furnished without charges of any kind.

When a boy knows just what trade he desires to learn, he is permitted to start in that line of work and give most of his attention to it. If no such choice is expressed, several lines of trade are started at first, and then, under the advice of the instructor, some one is selected, according to the aptitude which is developed, after



MOTOR-DRIVEN RIP-SAW BENCH



MOTOR-DRIVEN CABINET SURFACER



MOTOR CONNECTED TO UNIVERSAL SAW BENCH



WESTINGHOUSE MOTOR RUNNING CUT-OFF SAW



ELECTRICALLY DRIVEN MACHINERY IN THE NEW YORK VOCATIONAL SCHOOL

which the entire time is given to the work thus chosen. The boys work in groups, but these are not classes in the ordinary sense of the term, all instruction being individual. Each boy is treated as a unit, and progresses as rapidly as his ability will permit.

The courses include woodworking, metal working, printing and book-binding.

In the woodworking department, portions of which are shown in the photographs, the divisions cover house carpentry and construction, cabinet-making and bench work, wood turning, pattern making and the use of woodworking machinery.

The electric motors are of the induction type, operating at 1,700 revolutions per minute on a 220-volt, two-phase, 60-cycle current supplied from a central station. These motors, as has already been stated, were made by the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa.

Technical Automobile Work

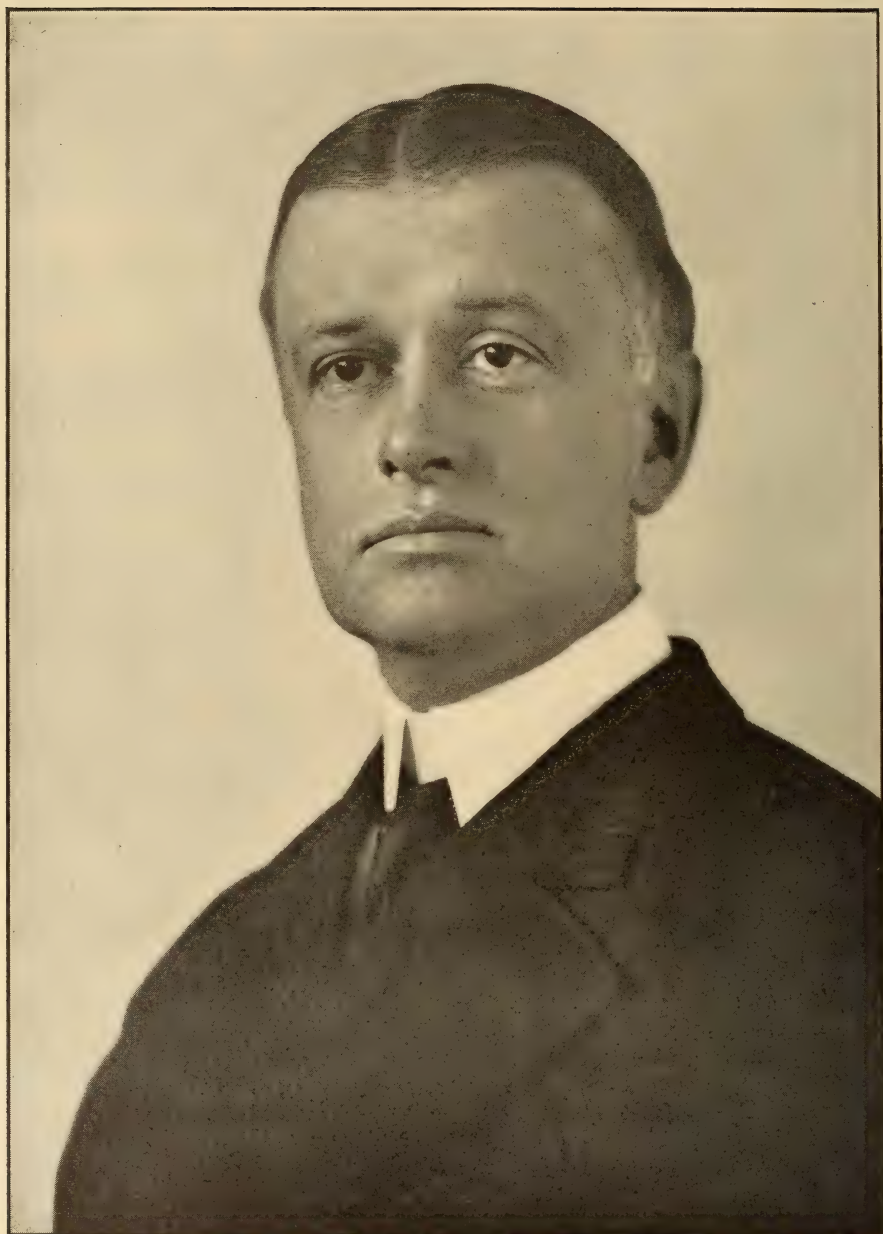
The Regal Motor Car Company has just added a new department to its institution, with a view of further carrying into force the principle of service. This department will be known as the technical department, and goes hand in hand with the repair and trouble department, and the department supplying extra parts.

In charge of this department has been placed Mr. Virgil Oldberg, formerly president of the Oldberg Manufacturing Company, of Detroit, manufacturers of mufflers and other automobile appliances. Mr. Oldberg is a young man with an excellent education and wide experience in the work that he undertakes. He is a graduate of Cornell Engineering Department and was a teacher there for a number of years following his graduation. He interested himself along inventive lines and several inventions are the result of his handiwork and brain.

Irving T. Bush, whose portrait is given this month, is an excellent example of the man who unites the business capacity of the man of affairs with the utilization of technical and engineering ability in the solution of commercial problems.

Born at Ridgeway, Mich., in 1869, and educated at the Hill School at Pottstown, Pa., Mr. Bush has devoted his energies toward the realization of a scientific terminal in New York for shipping and manufacturing interests. The result of his efforts is appearing in the Bush Terminal, providing both docking facilities for vessels and space for manufacturing industries in such close proximity as to eliminate almost wholly the artificial and unnecessary burden of hauling and useless handling of merchandise.

He is president of the Bush Terminal Company and its associated corporations; a member of the advisory board of the Title Guarantee & Trust Company, and a director of the Merchants' Association of New York.



Photograph by Pirie MacDonald, New York.

IRVING T. BUSH

See Reverse Side.

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CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

VOL. XXXIX

FEBRUARY, 1911

No. 4

LUMBERING IN THE WORLD'S GREATEST FORESTS

By A. W. Day



A FIRE STARTING ON THE EDGE OF A WOODLAND

THE agitation in favour of conserving natural resources calls attention to the extent of forests of commercial timber in the United States and the great importance of the American lumber industry. While the forests, especially in the West and Northwest, cover the largest area of the world's woodland, the work of the lumberman has been of such wide activity that, in the States of Wisconsin, Michigan and Minnesota, the percentage of standing timber is rapidly diminishing, owing to the development of the in-

dustry in this region. The Forest Service of the United States, which has investigated the conditions, reports that these States will be exhausted as a source of timber supply within the next thirty years if lumbering operations are continued on the same scale as at present. No less than \$117,000,000 in value are cut yearly from this section.

The same situation exists in the Southern woodlands, where many of the pine and cypress forests have been cut off. The annual value of the output of Louisiana, aggregating \$35,000,000, is an illustration of the extent of the Southern lumber industry; but the logger is working in the pineries of Florida, Mississippi and Georgia, and the pine trees of commercial value in the Carolinas have been felled.

What the tree means as an asset to the nation can better be appreciated when it is stated that a conservative estimate of the capital now invested in the 30,000 logging camps and sawmills, as well as associated industries, is no less than 1¼ billion dollars, while the value of the yearly output is actually over 1,500 million dollars including all products, and the number of men employed 875,000. The yearly output has increased from



A GREAT LOG IN A WASHINGTON FOREST BEING CUT INTO SLABS FOR TABLES

18,000 million feet in 1880 to nearly 40,000 million feet a year. As centres of timber production the following States are the most important, given in the order of their rank.

Washington, \$50,000,000 value output.

Wisconsin, \$45,000,000 value output.

Michigan, \$40,000,000 value output.

Louisiana, \$35,000,000 value output.

Minnesota, \$32,000,000 value output.

Pennsylvania, \$30,000,000 value output.

These figures show that lumber industry is one of the great sources of revenue to what might be called the Superior group of States—Minnesota, Wisconsin, Michigan—while the South is yet an extensive producer, not merely of pine, but also of certain hardwood and cypress; but, as already stated, the investigations which have been made show that the timber supply in the Lake Superior States is being cut at such a rate that it will be exhausted in a certain number of

years. The same is true of the Southern States, consequently the United States must look to the far Northwest for its future supply of high grade lumber, although in the States of Washington and Oregon this industry has assumed such proportions that no fewer than 1,200 industries, employing 50,000 men with a capital of \$15,000,000, are to-day in operation, the quantity of lumber yearly being manufactured into building material, railroad supplies, marine work, and for other purposes aggregating in these two States alone no less than 3,500 million board feet. The four hundred and fifty lumber mills in the State of Washington turn out over thirty million feet of finished produce daily. The output of the Oregon mills is much smaller, the plants being very few compared with the State of Washington, having an annual value in output of but 15 million dollars. A comparison of the timber resources of the two States brings out the fact that, as yet, but an insignificant fraction of the Oregon forests have been cleared, and that the supply of timber is so enormous as to seem almost



A TYPICAL LUMBER TOWN IN THE GREAT FIR FORESTS OF WASHINGTON. THIS PLACE PRODUCES NOTHING BUT LUMBER



THE OLD METHOD OF CUTTING TREES, SHOWING THE WASTE OF LUMBER

The portion of the log below the platform on which the men are standing is left to rot.

incredible. An estimate made within a year by United States forest experts shows that, by actual survey, this State contains no less than 29,000 square miles of woodland—over one-fourth of the total size of Oregon. The forests, which include what is termed Oregon pine—another

name for the Douglas, or yellow fir in Washington—also red cedar in extensive growths, have been measured by the surveyors of the Forest Service and their report is to the effect that fully 210 billion feet, board measure, are still standing. These figures were secured by getting



AN AVERAGE OREGON FIR LOG



AN EXAMPLE OF THE ENORMOUS WASTE IN OLD-TIME LUMBERING

The portion of this log below the cut contains over one hundred board feet, but is not used, and left to be wasted.

the height and diameter of different sizes of trees in the several forests, and computing from this data. The State of Washington, containing but

69,000 square miles, is less than three-fourths the size of Oregon, but its available timber area, based on the estimates of the forest expert, is



TRUNK OF A FIR TREE 6 FEET IN DIAMETER CUT THROUGH BY POWER SAW OPERATED BY GASOLINE ENGINE

equal to 195 billion feet, over half of it the Douglas fir. This gives a grand total for the Pacific Northwest of no less than 305 billion feet, making it by far the world's greatest growth of high-grade timber.

Nowhere else in America are trees found that are as large in weight and in general dimensions as in the fir forests of these two States. The sequoias of California have been termed the largest, but none of them have the height of the larger firs, while many of the latter have a thickness of 14 feet. Trees 10 feet in diameter are numerous and those less than four feet are considered small. As to the quality of the wood, the fir has been thoroughly tested by use since the beginning of its manufacture into lumber, and the results show it has great tensile strength, and is extremely durable, while for general use it is far superior to any other species of tree which exists in extensive forests, with the exception of such hard woods as oak or hickory. In the form of lumber it withstands the elements and variations in

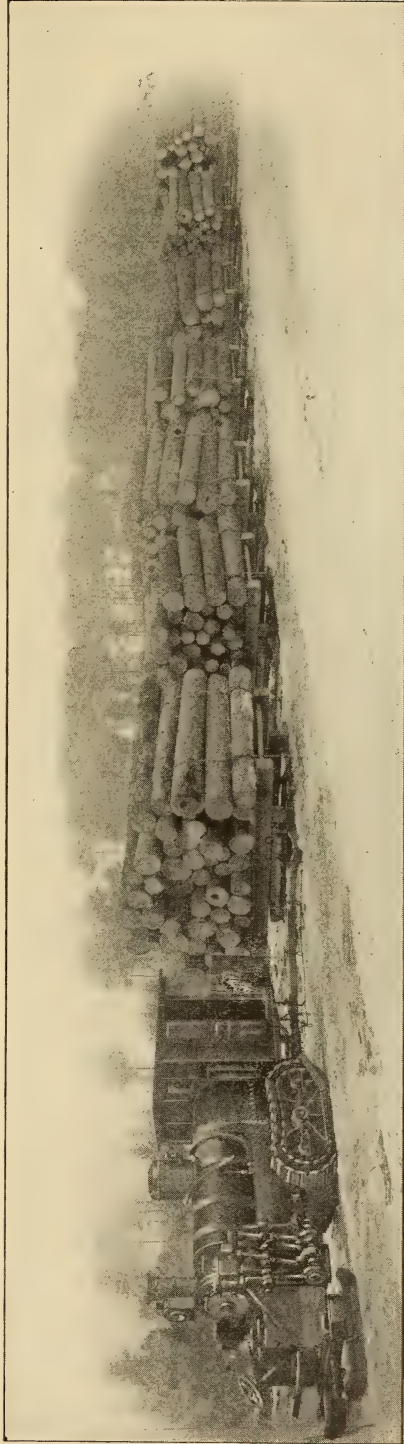
temperature far better than other kinds of wood used for building material. Some of the Oregon forests of this tree embrace a hundred square miles and the government has so realized the great wealth and value of this national resource that it has reserved $4\frac{1}{2}$ million acres for the nation as a precaution against the exhaustion of this valuable timber by the work of the lumberman, while the district is also carefully patrolled to furnish means to extinguish any fire that may occur.

It is because of this abundance of raw material that the lumbering operations in the Pacific Northwest, with few exceptions, are carried on, with no regard to economy or care for preservation of this valuable resource, although the doctrine of conservation of timber lands, if there is to be a permanent supply, is well known to the Northwest. At the present time, the percentage of waste in cutting these valuable forests and converting them into lumber is enormous. The stumpage is only one item, although in the vicinity of a

short space of Seattle one can see thousands of stumps, some of them of such diameter that the timber in them would be sufficient to build a small house or barn, left to rot where the portable shingle mills have not been installed. As yet, but very few of these mills have been put in operation compared with the extent of the cleared land. While a mechanical saw has been invented, operated by a gasoline engine, which will cut the trunk through, it has yet only been introduced into these forests.

To give a clearer idea of the quantity of lumber which a fir or Oregon pine will yield, stand one of the largest Georgia pines beside a big fir on the shores of Puget Sound and it would look like a little sapling. Some of these trees of the Northwest rise a hundred feet before they put out even the first branch, and most of what the lumberman calls the *medium growth* average at least six feet through at the butt and may reach a height of over 250 feet from the roots. Right here is one reason why there is such a great waste in logging in the Pacific Northwest. The timber cutter usually drives his axe into the trunk so high from the ground that, as we have already stated, the stump which is left may be ten or twelve feet above the roots. Seldom does he make a cut lower than six feet above the ground. Ask him why, and he will tell you that he wants to avoid any rotten spot which may be near the roots. Instead of taking the trouble to bore a small hole in the center to find out if any part of the heart is decayed, he simply cuts it from where he thinks the trunk is sound and often leaves as much good wood in the stump as can be sawed out of one of the smaller pines which are continually being cut for lumber in the Southern forests.

A word about the decayed spots. The fir is such a vigorous and hardy tree that seldom is the heart rotten, except, possibly, a few inches in the very centre, and near the ground. If



AN ICE LOCOMOTIVE FOR HAULING LOGS FROM THE WOODS IN WINTER



A DONKEY ENGINE FOR DRAGGING OUT LOGS FROM THE FOREST AFTER CUTTING

it is decayed in any way a few minutes' boring with a small auger will quickly determine this fact, but the tree cutters will not even take the trouble to do this. In the logging operations, the felling of one of these trees requires much skill, in order that it may not be broken in the fall, as such an accident means perhaps the loss of fully \$500, owing to the value of the wood. As yet, however, the old method prevails, of cutting it part of the way through with the cross-cut saw worked by two men, the axe being used for an incision on the opposite side, the trunk being felled by means of wedges. In felling the tree, a number of smaller ones are frequently cut down to form a bed on which it may fall, so that it will not break, on account of its weight. Here is a great waste, since the felling of a fir 150 tons in weight may require the sacrifice of a group of other trees which, at maturity, would equal it in size. In the "clearings" may be seen thousands of the young trees which

have been cut down merely for "beds." Undoubtedly a mechanical system could be utilized in the work, such as a portable power derrick, the top of which could be attached to a tree by the block and tackle system, thus allowing the trunk, when cut through, to be lowered gradually by means of ropes of steel cable, without the timber being injured and the crushing of the smaller trees near it. Here is, indeed, an opportunity for the introduction of a tree cutting system which would be taken up by the lumber companies throughout the Pacific Northwest.

The tree trunk is usually cut where it falls, into lengths, depending upon the use to which it is to be put, ranging from 140 feet, for bridge timbers, to sections 20 and 30 feet in length. Much of this work is still done by cross-cut saws, although the gasoline engine, connected with a cutting gear, has been placed in service by some of the larger companies. By this means trunks can be sawed in one-fifth of the time required by hand labor. On



THE FIRST ATTACK ON THE WILDERNESS. TIMBER "CRUISERS" MEASURING TIMBER IN FIR FOREST



AN OREGON SKIDWAY, SHOWING THE WASTE OF MERCHANTABLE LUMBER

Puget Sound another method is used, an electric wire being heated by the current and the log burned through. This method is very economical of material, for the reason that there is no waste in the form of saw dust.

One of the most difficult problems in logging in these forests is to get the logs out of the woods to the water way or the railroad for conveying them to the mills. In the construction of skidways and lumber roads is another waste of good lumber which is really enormous in its extent. It is a common practice for the lumbermen to fill up gullies along the roadway with limbs of fir and trunks from young fir trees, some of which are actually two feet in diameter, and would sell for a high price in the market.

While the crude, expensive and slow method of hauling logs of the fallen trees to the tram road or waterway by means of oxen and horses is employed in this region, some of the larger companies, whose experts are familiar with the use of mechanical aid, utilize steam power,

at a great saving in time and labour. Both the stationary and the movable engine are employed. They range from 60 to 100 horsepower. The stationary engine is usually mounted on blocks sawed from the trunks, to give it a firm base. The drum or cylinder attached to it holds a coil of steel wire cable which, when extended, may reach a distance of a half mile. When a tree is felled and sawed into sections, it is removed by passing the cable around one of the larger or two or three of the smaller logs, which are hauled to the engine by winding in the cable. The engine is usually placed near a tram road so the logs can be rolled up an inclined frame-work and placed on flat cars. As much as 175,000 feet in a day can thus be loaded. For the larger logs, however, it is necessary to have a lifting apparatus. A jib derrick, actuated by steam power, lowers the jib above the log and attaches a cable noose to one end. It is then lifted and the jib swings around and over the car so that the log need only be pushed into place by bars.



A CORNER OF THE GREATEST LOG HOUSE IN THE WORLD, SHOWN AT THE SEATTLE EXPOSITION

Some of the lumber railways in operation in Washington are 100 miles in length, terminating at a group of saw-mills and being owned by companies whose land holdings are located at various points along the route. Thus a co-operative system is followed which lessens the expense. The largest lumber mills in the world are situated, in part, in the Pacific Northwest, which accounts for the enormous annual output of timber in these two States. One of

these plants is situated a few miles from the city of Seattle at what is known as Port Blakely, on Puget Sound. Its location is such that the timber for 100 miles around on the mainland and islands can be cut, hauled to the water's edge, and floated to the booms. This mill employs more than 500 men and is equipped with modern machinery for sawing the trunks and converting the fir wood into girders, planking and other work. Its output is no less than



THE LARGEST LUMBER MILL IN THE WORLD. PORT BLAKELY, WASH., NEAR SEATTLE

The logs of Oregon fir are floated into the boom in the foreground, while in the distance are seen masts of the vessels in which the finished lumber is shipped to all parts of the world.

100 million feet yearly, having the greatest capacity of any lumber mill yet built. At the wharf may be seen steamships and sailing ships loading the timber for the foreign market, as the Oregon pine and the Washington fir are in great demand for the markets of Southern and Central America, as well as of Europe, since this timber is so especially adapted for a variety of purposes.

In converting the logs into lumber for commercial purposes, the sawing equipment has to be of the best design and construction and operated at a high speed. As the log coming to the mill has been cut in the woods to the proper length, most of the work is confined to lengthwise sawing. For the larger sizes a band-saw mill is employed. The endless blade is of specially tempered steel and when in operation is cooled by a stream of water to prevent the intense heat from friction in cutting through the log from warping it. Before being

sawed, all of the fir timber is left in the boom for several days to soak in the water. From the mill to the boom extends an inclined plane equipped with revolving rollers connected to the mill shafting. The lumbermen push the end of a log upon one of the rollers which is submerged. The roller carries it up the incline to the next roller and so it passes until deposited on the saw carriage. Usually it is sawed in halves, each half falling upon conveyors, which automatically stop when it is free from the table. Then one of the halves is run back and forth until it has been converted into planking or girders or whatever may be desired. As the machinery is duplicated, this accounts for the large capacity of the Port Blakely plant, but many of the largest mills in Washington are provided with modern equipment of the same type.

But as extensive as is the lumbering industry in the Pacific Northwest,



WATER-POWER IN WASHINGTON UTILIZED TO GENERATE ELECTRIC CURRENT FOR RUNNING LUMBER MILLS

as yet it is in its infancy. The great area of the untouched forest, composed of timber superior to that of any other wooded area of large dimensions in America, means that as fast as their supply of raw material is exhausted the lumberman of Minnesota, Wisconsin and Michigan will go further

West. Such is the expansion in this industry that each year finds a large increase in the capital interested and more and more clearings are being created by the logging camps. This is one reason why these great resources should be carefully protected, and apparatus which is not merely labour and time-saving but will obviate

the present wasteful processes should be installed.

Another indication of the extent of this resource, especially in Oregon, is shown by the forest fire statistics. An enormous loss has been caused in this State merely by fire destruction. In some parts of it great conflagrations have burned for months amid the western foothills of the Cascade Mountains and in the region between the Cascades and the Rocky Mountains, spreading over a territory so great that nothing could be done to check the ravages of the flames. The regions swept of timber wealth from this cause have been measured by the forest experts. They had the same growth in dimensions as the fir, cedar and other trees now in the forest. The measurements showed that no less than 689 square miles of these forests have been utterly ruined within ten years and that fully 54 billion feet of high-grade lumber,

worth \$50,000,000, have been lost merely from this cause.

The havoc wrought by fires may be seen when traveling on the railroads of this district. Only those who have journeyed along the railroads of the Pacific Northwest can appreciate the ravages of fire. We speak about the destruction by fire on the prairie, sometimes of farm houses, when the prairie grass becomes dry so that it ignites. Occasionally fire sweeps through the so-called forests of the East, but these are merely bonfires compared with the work of the flames in the great woodlands on the slopes of the Rockies and the Cascades. The fir forests are notable for their dense growth, the trees being so near together that sometimes one can go through the leafy aisles and only see the sky by chance. The "logged-off lands" form one of the principal sources of the forest fires. After the trees have been cut down,



THE DESOLATED PATH OF A FOREST FIRE



THE REFUSE KILNS OF A GREAT SAW-MILL IN WHICH VAST QUANTITIES OF VALUABLE LUMBER ARE DESTROYED

the sap in the stumps dries out rapidly and they begin to decay in a short time. Then they are literally masses of tinder which may take fire even from the match carelessly dropped after a settler has lighted his pipe.

In getting rid of the stumps, fire is often used. As many of the smaller clearings are surrounded by forests of second-growth, if not first-growth trees, if the wind drives the flames into the forests or the fire gets beyond control of the farmer it may start a conflagration which will burn for weeks and turn mile after mile of woodland into a smoking and blackened ruin. The heat of these fires is so intense that no one can go near enough to the burning area to throw water upon the flames even if enough water could be secured to extinguish them. Nor can they turn up the earth in furrows, as the men of the prairies do in fighting the grass fire and thus stopping it for want of fuel.

There are places on the Northern Pacific Railroad where the track has literally been destroyed for stretches

of twenty-five and thirty miles—ties turned to ashes and rails twisted and warped so that they are fit only for the scrap heap. The smoke of a fire which ravaged a part of the Puget Sound country in 1906 was so dense and in such quantity that a west wind actually blew it as far as the city of Spokane on the other side of the Cascade Mountains, in eastern Washington, a distance of three hundred miles.

This is why the States of both Washington and Oregon have adopted very rigid fire laws. These laws make it a criminal offense for anyone to kindle a fire for cooking or heating, even in the open field, without extinguishing it before he goes away. If a lumberman, settler or prospector should forget to put out even the embers of his camp fire and is caught afterwards, he stands the chance of spending a half year in prison. In fact, the forest fires have done so much damage that the farmers look upon an offender of this sort very much as the people of the plains regard the horse thief. The timber cut-

ters themselves are largely responsible for starting many of the big fires, because they seem to care nothing for the immense waste in the industry.

For this reason the Bureau of Forestry advocates new methods of felling trees, such as using saws driven by steam power, which will cut the trunks close to the roots. A law is also being advocated, com-

PELLING the timberman to bore into the base of the tree and not leave the decayed spots to guess-work. Laws of some sort are certainly needed, for it is estimated by the forestry experts that of the total amount of timber cut for various purposes in this region only sixty-five per cent. is actually saved, and that the enormous proportion of thirty-five per cent. is actually left in the forests to waste.



INTERNAL COMBUSTION ENGINES AT THE BRUSSELS EXHIBITION

By Percy R. Allen

TO anyone already fairly familiar with the subject, the internal-combustion engines shown at the Brussels Exhibition presented many points of interest. Much has been accomplished during the past decade in developing both the gas and oil engine, and, although the primary object of the present article is to describe the gas engines actually exhibited, a brief summary of the lines along which development generally has taken place is given at the end of the chapter.

It may be remarked that it is just ten years ago that the John Cockerill Company, of Seraing, showed, at the Paris Exhibition in 1900, the first really large gas engine that had been brought before the notice of the public. This was a single-cylinder, single-acting engine of the open-trunk type, with a blowing cylinder behind it, and was nominally of 600 horse-power. At the present exhibition the same firm exhibited a twin-tandem, double-acting gas engine of 3,000 horse-power, also intended for blowing purposes, and the differences in the method of construction illustrate very well the direction in which the large gas engine has been developed. Ten years ago the few 1,000 horse-power gas engines which were at work or under construction had four open trunk cylinders placed in pairs on opposite sides of the crankshaft, 250 horse-power being then regarded as the limit of an individual cylinder. Now it is no uncommon thing to use cylinders of the closed and double-acting type which will develop 1,500 horse-power in each cylinder, and this in a four-stroke cycle engine. In a two-stroke cycle engine the

power can be carried higher, and several of the German licensees of the Körting patent have built engines in which 2,000 horse-power is developed in a single cylinder. This means that a twin-tandem engine of this type could be built to develop 8,000 horse-power. All this progress has been made during the past ten years; in fact, most of it during the past eight years, as the open trunk design for large engines was only abandoned by the leading makers after the Düsseldorf Exhibition of 1902.

The Cockerill type of engine is built in Great Britain by Messrs. Richardsons, Westgarth & Co., and licenses to build have also been taken out in most of the Continental countries; but, as these licenses derive their inspiration from Seraing, the engine shown at the exhibition may be taken as representing the most up-to-date construction of this type. The chief particulars were as follows:

There were four cylinders, $39\frac{3}{8}$ inches in diameter with a piston stroke of $43\frac{3}{8}$ inches, coupled to cranks at right angles on the crankshaft, carrying the fly-wheel between the two side frames. The two blowing cylinders were placed in the rear and worked by prolongations of the back piston rods. When supplied with blast-furnace gas having a calorific value of 950 calories per cubic metre, the engine will displace 35,000 cubic feet of air per minute and deliver it at a pressure of two atmospheres, the engine running at the normal speed of 80 revolutions per minute. The illustration in Fig. 1 brings out the distinctive features of the latest Cockerill de-

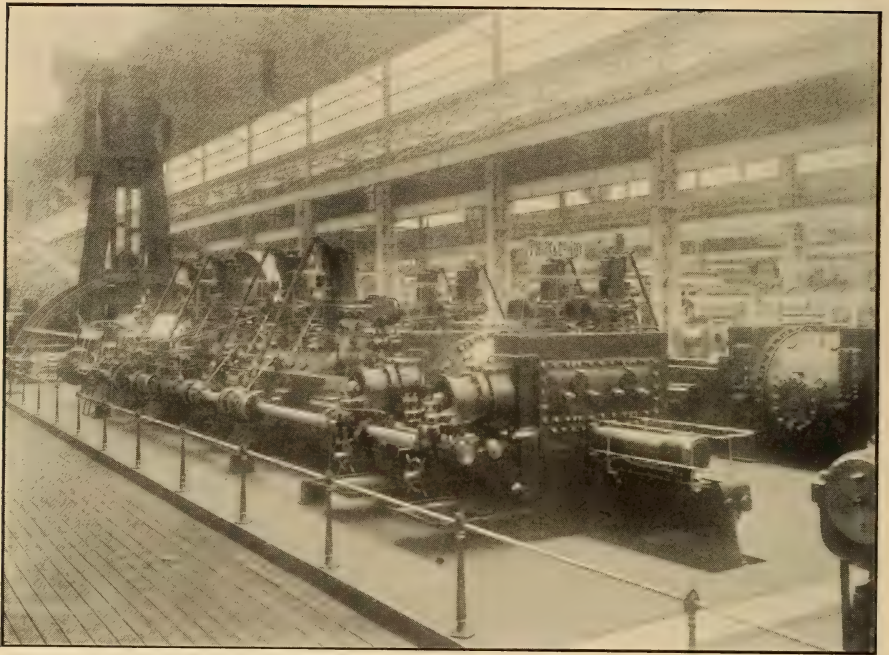


FIG. 1.—TWIN TANDEM BLOWING ENGINE, 3,000 HORSE-POWER. SOCIÉTÉ ANONYME, JOHN COCKERILL

sign. It will be seen that the framework is in the form of a girder with supports directly under the cylinders, the crossheads working in guides formed in the side of the frame. A distinctive feature of this engine is that the working cylinder is reinforced by through bolts so arranged that the explosion stresses are transmitted almost directly to the main frame. In the latest design of these engines the valve gear has been considerably simplified; in fact, all makers of large gas engines have for years past been endeavoring to produce close regulation and good distribution with as simple mechanism as possible.

As a contrast to this modern gas-driven blowing engine there was exhibited in the same stand an old, vertical, steam blowing engine, which was put into service fifty-seven years ago.

It must be admitted that the Cockerill Company showed considerable public spirit in going to the expense of erecting and putting into working order such a large engine

for exhibition purposes; but, as the Seraing Works are regarded in Belgium as having a national importance, the exhibits may be taken as representing in some respects the mechanical capabilities of the country.

Next to the large Cockerill engine, the engine which apparently attracted most attention in the Belgian section was the new-pattern, 100 horse-power gas engine exhibited by La Société Anonyme des Moteurs à Gaz, A. Bollinckx. The firm of Bollinckx has for many years been established in Brussels as builders of large horizontal steam engines, and, although some of these engines showed an extremely good steam consumption, the makers frankly realized some years ago that the gas engine, as a motor, must show a much superior thermal efficiency to a combination of a steam engine and steam boiler, or even to the steam turbine, of which they are now also constructors, and they, therefore, in 1902 erected a new works a few miles from Brussels, which is now devoted solely to the building of gas engines

and gas producers. The engine shown at the exhibition was of the horizontal, open-trunk type, and worked on the ordinary Otto four-stroke cycle. While there was nothing extraordinary about the general appearance of the engine, as will be seen from Fig. 2, the frame was of graceful outline, the metal being well distributed, and the details of construction had evidently been very carefully considered. In this type of single-acting engine, where the breech piece forms the explosion chamber and is, at the same time, the back cylinder cover, a good deal of skill has to be exercised in designing the necessarily complicated casting so that it shall be, in the first place, free from casting strains, and, at the same time, strong enough to resist the force of the explosion. It must, moreover, be of such a shape that there is a certain freedom for expansion, in order that the heat generated during working conditions will not set up stresses leading to the fracture of the casting. The question of the best circulation for the cooling water is also a matter that has to be taken into careful consideration. In this engine the cooling water enters the breech piece first, passes directly to the jacket, and, after leaving the cylinder, passes round the exhaust pipe.

This arrangement has proved so far effective that it has been found that the engine can be run continuously with the cooling water issuing at boiling point without any signs of pre-ignition. One cam only is used for actuating both the inlet and exhaust valves, and a system of variable admission is employed, in which a sensitive governor controls a steel blade, which is moved nearer to or further from the fulcrum of the lever actuating the valve spindle. In this case the governor has only to indicate the position that the blade shall take, and is subject to no reaction from the movement of the cam; indeed, the blade may be considered as floating except at the moment it is in contact with the admission lever. The governor and the gears driving it are enclosed in an oil-tight case, and very complete lubrication is provided throughout the engine. The bearings of the crank and cam shaft are fitted with patent roller oiling arrangements instead of the ordinary ring lubricators. The flywheel was cast in one piece and keyed tangentially to the main shaft, as shown in Fig. 3, and the makers appear to lay considerable stress on this method of fixing.

The suction gas producer developed by Messrs. Bollinckx for use with their gas engines is illustrated

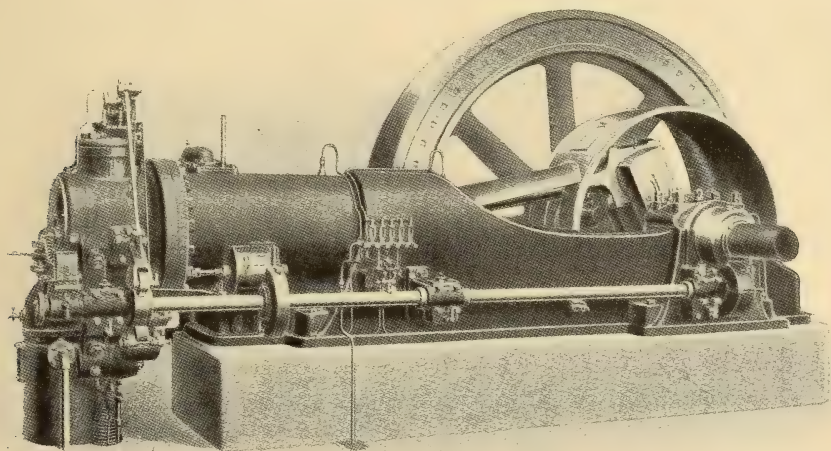


FIG. 2.—SINGLE-ACTING GAS ENGINE, 100 HORSE-POWER. SOCIÉTÉ ANONYME DES MOTEURS À GAS, A. BOLLINCKX

in section by Fig. 4. No grate bars are used, but a hearth that is capable of being occasionally revolved sustains part of the burden of the fuel. This revolving hearth has a large hole in the centre, through which the burnt ashes fall and rest in the form of a cone on a fixed hearth below. The revolving hearth is controlled by a hand wheel outside, and under ordinary conditions it is necessary to revolve it only about once a day. The vaporizer is a cast iron vessel having a series of fin rings cast round it, which serve to retain the water and evaporate it rapidly as it overflows from a preliminary heater on the top of the producer. Any deposit on these rings can be cleaned out while the producer is at work. This construction of vaporiser keeps the interior surface of the producer sufficiently cool at the hottest part to prevent the formation of clinker. An inspection of the illustration will show that the gas passes from a central

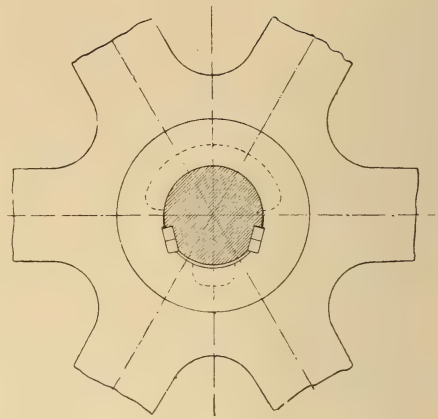


FIG. 3.—METHOD OF FIXING FLYWHEEL ON SHAFT OF 100-HORSE-POWER ENGINE

tube about half-way up the producer to the bottom of a rather large scrubber without any intermediate separator. The producer is started in the ordinary way by a small hand-worked fan, and the chimney valve is

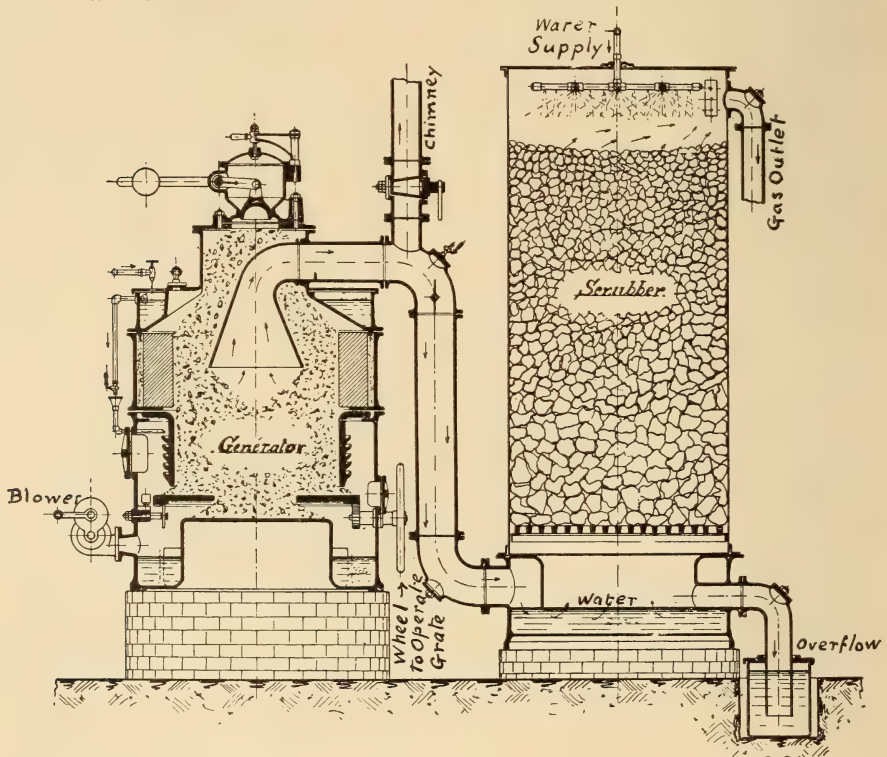


FIG. 4.—BOLLINCKX SUCTION GAS PRODUCER

kept open until the gas is of proper quality to be directed to the scrubber, the producer then being worked like any other ordinary suction system.

Besides the exhibits of the Cockerill Company and the Société Bollinckx, there were about half a dozen Belgian exhibitors in this class, these being the Ateliers Moes à Waremme; Ed. Hanappe et Cie., Brussels; Alphonse Roland, Brussels; Ryziger René et Cie., Brussels; Société Anonyme des Ateliers Onghena; Société Anonyme des Etablissements Fetu-Defize, Liège; but as none of these people exhibited engines of more than 15 horse-power, and as they were all of substantially the same design, there was little to remark about them except that they were, on the whole, very good workmanship. Each maker seemed to have his own idea as to the precise form of valve gear to use; but in most cases, even in the smaller sizes, the governor controlled the opening of the gas valve and magneto ignition seemed to have largely superseded the hot tube.

In the French section a 50 horse-power Tabor motor was shown. This was a four-cylinder, vertical engine, and was exhibited in conjunction with a Bardot producer. It was stated that the engine would work equally well with illuminating gas, producer gas or oil, but the writer never saw it in operation.

In the German section a couple of gas engines and two smaller oil engines were exhibited by the Gasmotorenfabrik Aktien Gesellschaft Köln-Ehrenfeld, formerly C. Schmitz. These makers stated that since 1903 they had been engaged entirely in building gas engines and gas producers, and stated that their first suction gas plant of 25 horse-power was started in 1900, and has been working ever since without any breakdown. The 40 horse-power engine exhibited at Brussels is shown by the small illustration, Fig. 5, and was what the makers termed their new type "H5." They also showed in conjunction with this engine a suc-

tion producer for utilizing fine-grade anthracite slack. To prevent this material clogging the firebars, a step grate with rather wide spaces was used, as well as the flat grate at the bottom. Cleaning doors were provided at the level of the step rings and also opposite the ash pit; the preliminary heating of the water was done on top of the producer, whence it flowed over into the vaporizer surrounding the gates, afterwards entering the fuel bed with the air, the gas passing from the producer under the upper water heater and then into an annular casing round the top of the

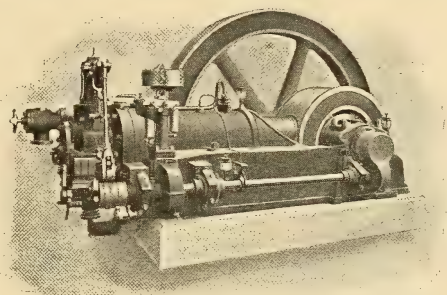


FIG. 5.—ENGINE, 40-HORSE-POWER, BY THE GASMOTORENFABRIK AKTIEN GESELLSCHAFT KÖLN-EHRENFELD, FORMERLY SCHMITZ

producer and onto the scrubber, where it passes through a water-seal at the base and on to the engine. The engine exhibited was of the ordinary four-stroke Otto type, with the water-jacketed cylinder cast into the bedplate, the loose liner being fixed at one end and free to expand. Forced lubrication was provided for the trunk by means of a small, independent oil pump worked by the lay shaft, and a small glass gauge was fitted in the cooling-water system which showed at a glance the head in the circulating pipes. The air supply to the mixing chamber was taken through a duct in the bed from the flywheel side of the engine, and the valve gear was what the makers termed their "constrained precision gear." This is illustrated in Fig. 6, which shows a rear view of the cylinder. The inlet valve proper and

the gas valve are both mounted on the same vertical spindle, which is kept pressed upwards by a spring against a lever pivoted on one side of the bonnet. This lever is actuated from the camshaft by another lever pivoted on the other side of the bonnet, the connection between the two being made by a small roller, which is moved in and out by the action of the governor, and thus transmits motion from the camshaft lever to the valve-spindle lever. It will be evi-

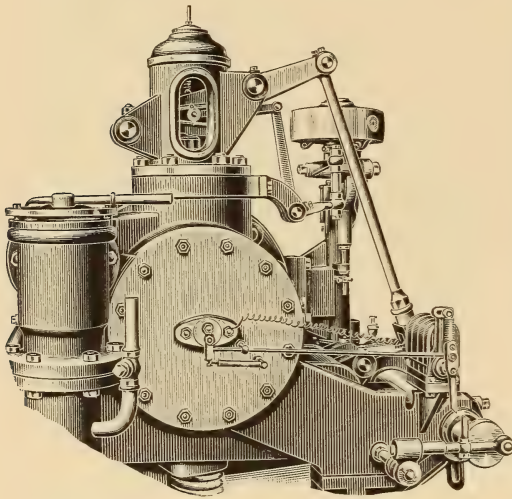


FIG. 6.—REAR END OF SCHMIDT 40-HORSE-POWER ENGINE

dent that the opening of the gas valve varies, as the governor causes the roller to vary its position and thus change the effective leverage of the two levers. This method of governing is, in effect, very similar to that used on the new National gas engines and the engine which was shown by Messrs. Ruston, Proctor & Co., and comes under the classification of "quantity" governing. The cylinder head was fitted with rather a neat arrangement for starting by compressed air, and the makers claimed some improvements in the ignition arrangements. The Maschinenfabrik Kappel, of Chemnitz, also exhibited in the internal-combustion engine class, but the engine actually shown was only a 12 horse-power oil en-

gine, although apparently they built gas engines in standard sizes up to 120 horse-power.

No large German gas engines were actually shown, but the Maschinenfabrik Augsburg-Nürnberg (known in England under the abbreviated title of "M. A. N.") exhibited in the German section a series of photographs of their large gas engines and installations. The general design of the Nürnberg engine has become almost standardized during the past few years, but recently the construction of the cylinders has been somewhat modified and the valve-gear again simplified and improved.

It is somewhat to be regretted that none of the makers of the large, two-cycle engine had anything to represent them in the exhibition, because the large two-cycle engine built generally after Körting's ideas has met with a very considerable amount of favour on the Continent, both for driving dynamos and working blowing engines, and is making very considerable headway in England.

The building of the Oechelhäuser engine appears to have been abandoned on the Continent, apparently for reasons of constructive cost; but the principle is still employed by one British firm—Messrs. William Beardmore & Co.—and their modified arrangement seems, apparently, a very efficient machine.

Coming now to the British section, it is gratifying to find that the leading firms who have been associated with the development of the gas engine in Great Britain made a very good representative show. Messrs. Crossley Bros., the Campbell Gas Engine Company, the National Gas Engine Company and Messrs. Ruston, Proctor & Co. all exhibited engines of their standard design, in three cases actually working with their own type of suction producers.

The English gas-engine builder is often reproached with want of enterprise in not developing the large gas engine, but the inducement to do this must come from the customer, and

where there is one inquiry for a 2,000 horse-power engine there are actual orders for twenty of the smaller sizes up to 500 horse-power; and, as far as vertical gas engines go, it may be said for the English makers that they have developed a design which has hardly as yet been touched upon the Continent.

Compared with a horizontal engine with one or two comparatively large cylinders and a heavy flywheel, the vertical engine with four, six or eight cylinders has the advantage of occupying but little floor space and having considerably lighter parts. The smaller cylinders used do not generally necessitate water-cooled pistons, and the higher number of revolutions per minute enable the engines to be coupled directly to electric generators. Against this must be set off the multiplicity of moving parts, each one of which involves a certain possibility of going wrong. However, the writer has now had several years' experience with vertical gas engines having eight cylinders arranged tandem, with entirely satisfactory results. These happen to be of the Westinghouse type, and none of their gas engines was shown at Brussels.

The engines exhibited in motion by Messrs. Crossley Bros., of Manchester, were fed from one of their own suction gas producers, which had a nominal capacity of 100 horse-power, and had been designed to deal with any Belgian fuel, whether bituminous or not. The general arrangement of this producer is shown in Fig. 7. The steam is generated in coils placed round the top of the producer, and the vapour passes down a pipe and enters the fuel bed along with the air after passing through a superheater at the base. The gas is taken from the top of the producer by a vertical pipe, which is water-sealed at the bottom, and it then ascends through a coke scrubber, on the top of which is mounted a filter filled with sawdust or shavings; but between the scrubber and the filter one of the makers' patent tar ex-

tractors is introduced, and the use of this, together with the final cleaning by the sawdust scrubber, renders the gas, even from a bituminous slack, fit to be used in the engine, and this without any complication in the design of the producer itself. The vertical engine shown in motion on the stand gave 110 brake-horse-power at 250 revolutions per minute, working with producer gas. This is the makers' standard design of vertical engine, and they are built up to 350 brake-horse-power. Up to 250 horse-power the speed is 250 revolutions per minute, and for the 350 horse-power size 180 revolutions per minute. Either speed is convenient for coupling to dynamos, and, at the same time, represent quite moderate piston speeds. The general arrangement of this engine is now fairly well known, and can be seen from the illustration, Fig. 8. The crank chamber is closed in like a high-speed steam engine, and the four cylinders work on the Otto four-stroke cycle, the trunk pistons being single-acting. The four cranks are so arranged that the two inner ones are in the same plane, and the two outer ones are also in the same plane, but opposite the inner ones. Very steady turning is obtained, and the cyclic irregularity was stated to be $1/540$ in the engine exhibited. The inlet and exhaust valves were placed in the cylinder heads and worked by push rods directly acted upon by cams on the half-speed layshaft in the crank-case.

The supply of air and gas is kept quite separate in the manifold up to the inlet to the actual valve chamber, and, as separate gas cocks were provided opposite each cylinder, in the event of temporary overheating any individual cylinder can be thrown out of operation for the moment until it is cooled down; and, incidentally, the arrangement used very much minimizes the effect of back-firing, as it prevents mixture being formed in the passages of the manifold. Governing is effected by a spring-loaded governor controlling the amount of air

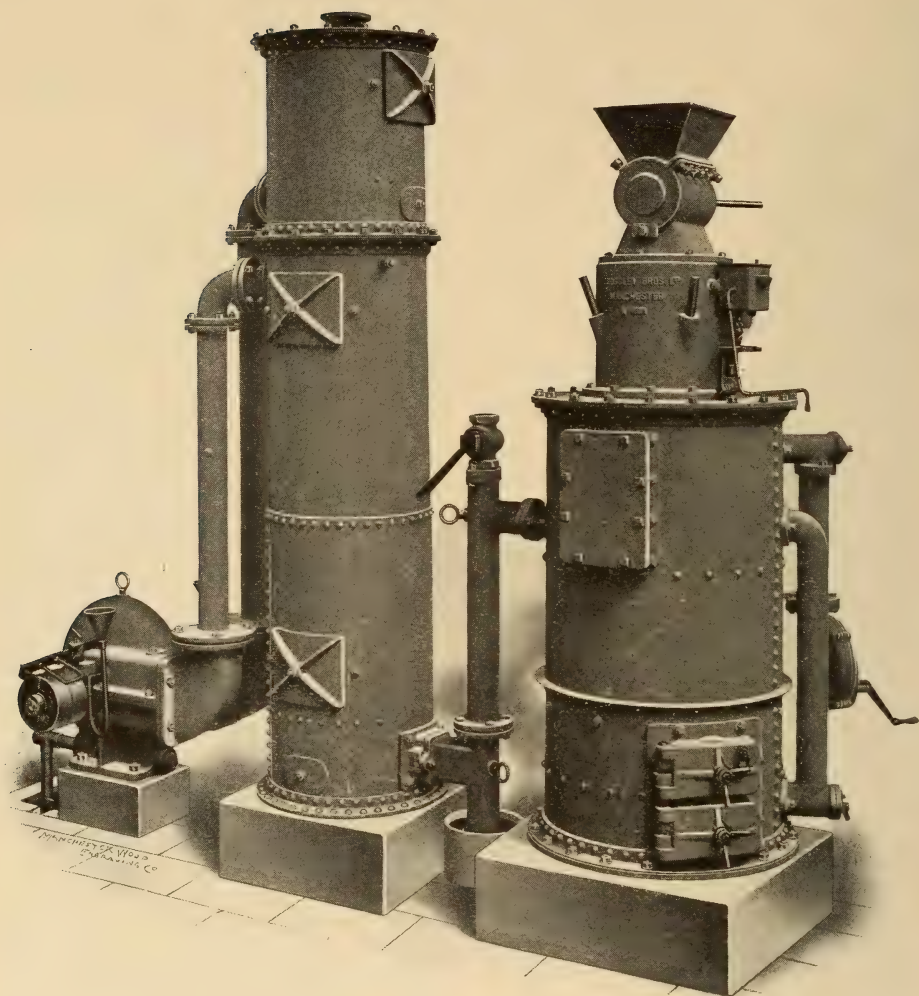


FIG. 7.—EXTERIOR VIEW OF CROSSLEY SUCTION PRODUCER

and gas entering the manifold, and the engine has an arrangement fitted to it so that it can be readily changed over to run with either producer or town's gas. The cylinder jackets and heads are water-cooled, but the trunks themselves are not. Forced lubrication is provided for by two valveless pumps worked by an eccentric on the crankshaft, the oil in course of circulation being passed through a gauze filter. High-tension electric ignition is applied, with provision for individual adjustment to each cylinder.

Messrs. Crossley also showed in operation a vertical engine which gave 65 horse-power when working on producer gas. This was of somewhat a new type, and the governor gear controlled the opening of the valve by varying the position of a swinging lever, as will be seen from the illustration, Fig. 9. This is a modified form of the arrangement used on the Deutz Company's engines, and in practice gives very close regulation. The large engine shown on the stand, but not in motion, was designed to give 175 horse-power on

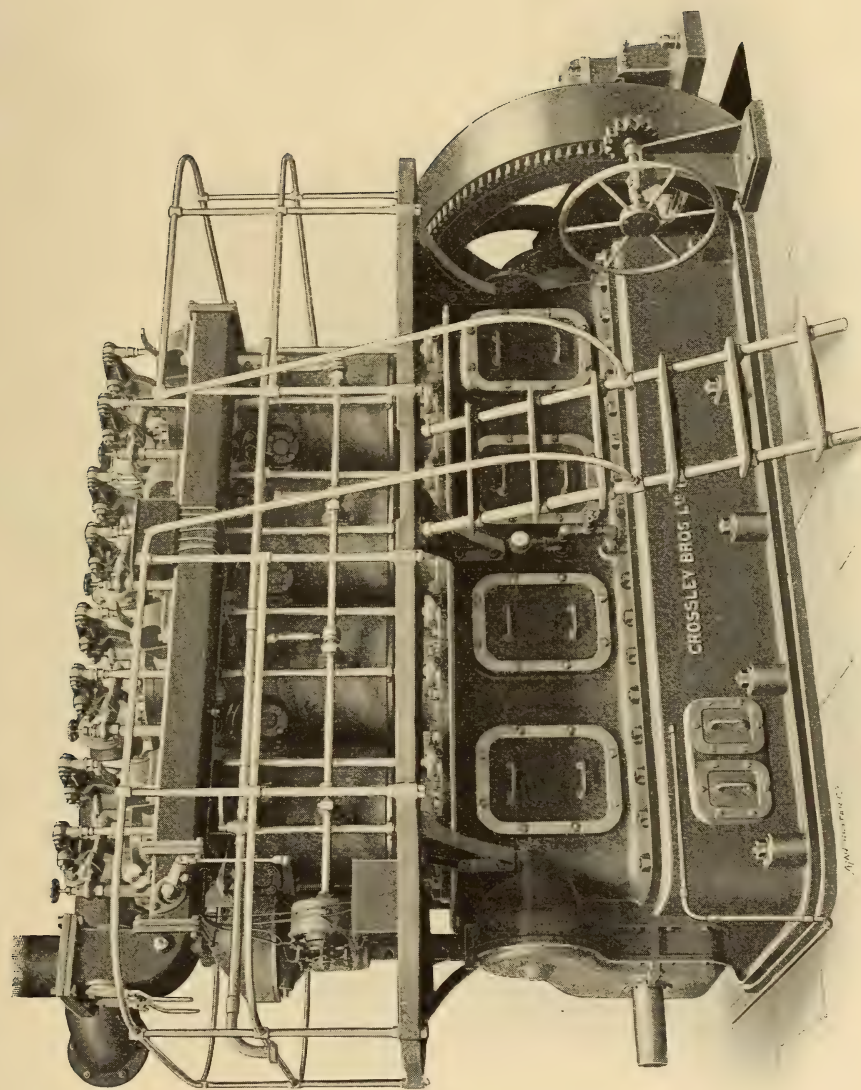


FIG. 8.—VERTICAL CROSLEY ENGINE

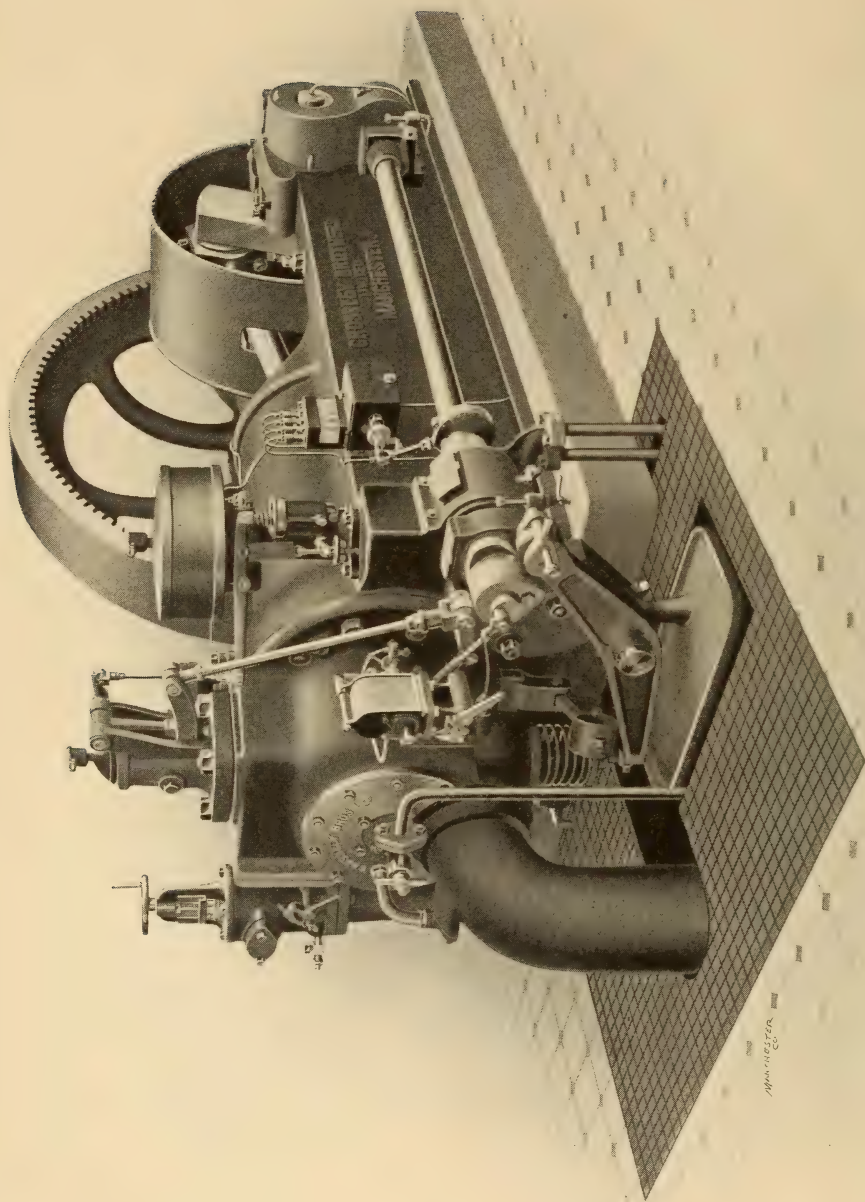


FIG. 9.—HORIZONTAL CROSSLEY-DEUTZ GEAR

producer gas, and was interesting as being fitted with Atkinson's patent pneumatic valve gear. This has been fully described in a paper read before the Institution of Mechanical Engineers, and consists of a rather elegant arrangement by which the opening of the gas admission valve is more or less retarded by means of a dashpot arrangement in which the vacuum, acting on the back side of the small piston attached to the gas valve, is controlled by a small air valve actuated by the governor, which can, therefore, be made very

sensitive, as it has very little work to do at any time and the amount of work is always constant.

A section through the back end of this engine is shown in Fig. 10, the gas valve being shown above the inlet valve. A small, vertical, two-cylinder engine, driving a 7-kilowatt dynamo running at 750 revolutions per minute, was also shown in motion at intervals. A grand prize in Class No. 20, Grays 4, was given to these makers.

Messrs. Crossley called attention to the fact that they have built 70,000

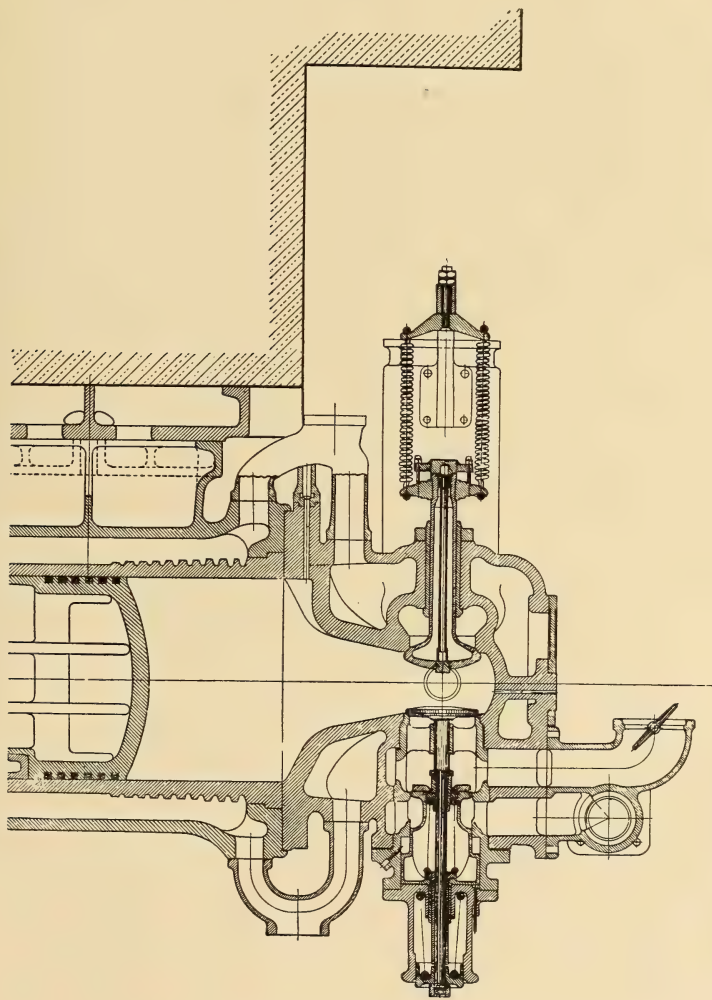


FIG. 10.—SECTION THROUGH CROSSLEY CYLINDER

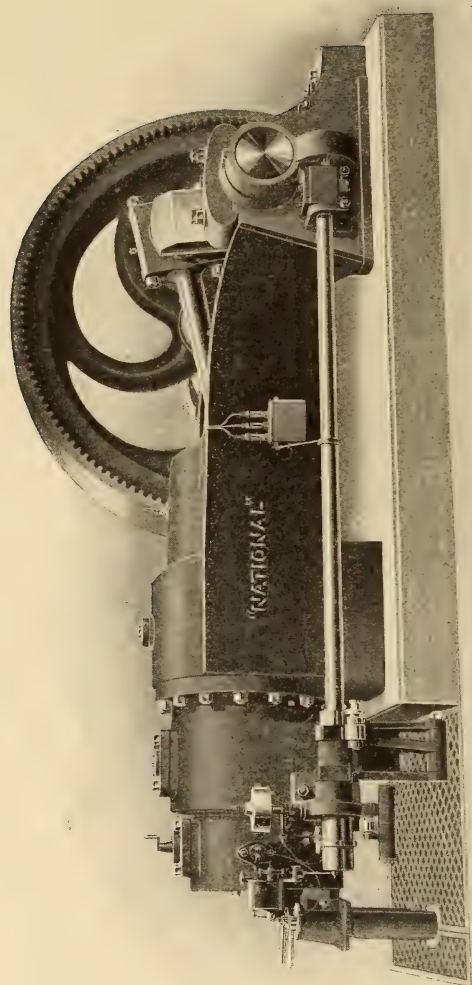


FIG. 11.—HORIZONTAL ENGINE, NATIONAL GAS ENGINE COMPANY

internal-combustion engines, and that they have been solely engaged in this all along, and have not grafted this on to the business of building steam engines, although, of course, the same statement applies to other makers, such as the Gasmotorenfabrik Deutz, the Campbell Gas Engine Company, of Halifax, and the National Gas Engine Company, of Ashton-under-Lyne. This latter company showed at Brussels a 100 horse-power horizontal engine and one of their standard type suction gas producers, but neither of these was in operation. The producer was of substantially the same design as the one that obtained the Gold Medal at Derby in 1906, and its general construction is well known. The vaporizer is at the top of the producer surrounding the annular space where the gas is collected prior to passing away to the scrubber. The hot gases, passing down the outlet pipe, give a preliminary heating both to the air and water supply. The 100 horse-power engine exhibited was of the type the makers have now adopted as a standard pattern, and it is illustrated in Fig. 11. It will be seen that the flame is of the girder pattern, with the cylinder liner built in the rear, so that there is very little overhang. The ignition is effected by two separate magnetos working independent ignition plugs on opposite sides of the cylinder, and the timing gear is so arranged that, while permitting considerable variation in the time of sparking, it ensures simultaneous ignition on both sides. The governing is effected by the makers' patent variable admission gear, shown in Fig. 12. It will be seen that the spindle carrying the gas and air valve is acted upon by a vertical lever pivoted at the bottom, while a cam on the layshaft imparts a constant movement to another vertical lever pivoted at the top. Motion is transmitted from one lever to the other by means of a suspended plate or thin die block, the position of which is controlled by the governor. As the speed increases the lever lifts the

plate nearer to the fulcrum of the cam lever and less motion is imparted to the spindle; as the speed falls the reverse action takes place. No more work is required from the governor than there is in hit-and-miss control, while the closeness of the regulation obtained enables the engine to be used for textile work and electric driving. The makers recommend that, in sizes above 100 horse-power, the engine should be started by compressed air and fit a timing gear on the layshaft for the purpose. This is a very simple device, and the writer has found that it answers admirably in practice.

The vertical gas engine which the makers are now building was not finished in time for the exhibition, but it was understood to be of the vertical tandem type.

The Campbell Gas Engine Company, of Halifax, exhibited a vertical, four-cylinder engine giving 150 brake-horse-power and a 120 horse-power horizontal engine, and also a

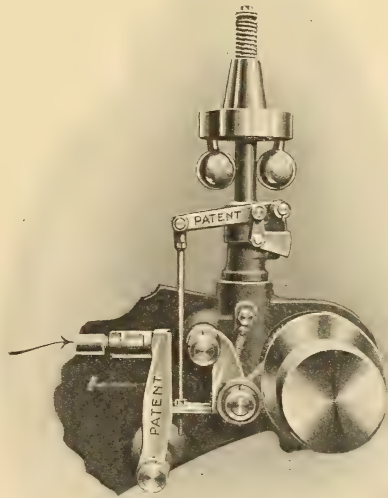


FIG. 12.—VARIABLE ADMISSION GEAR ON HORIZONTAL ENGINE OF THE NATIONAL GAS ENGINE COMPANY

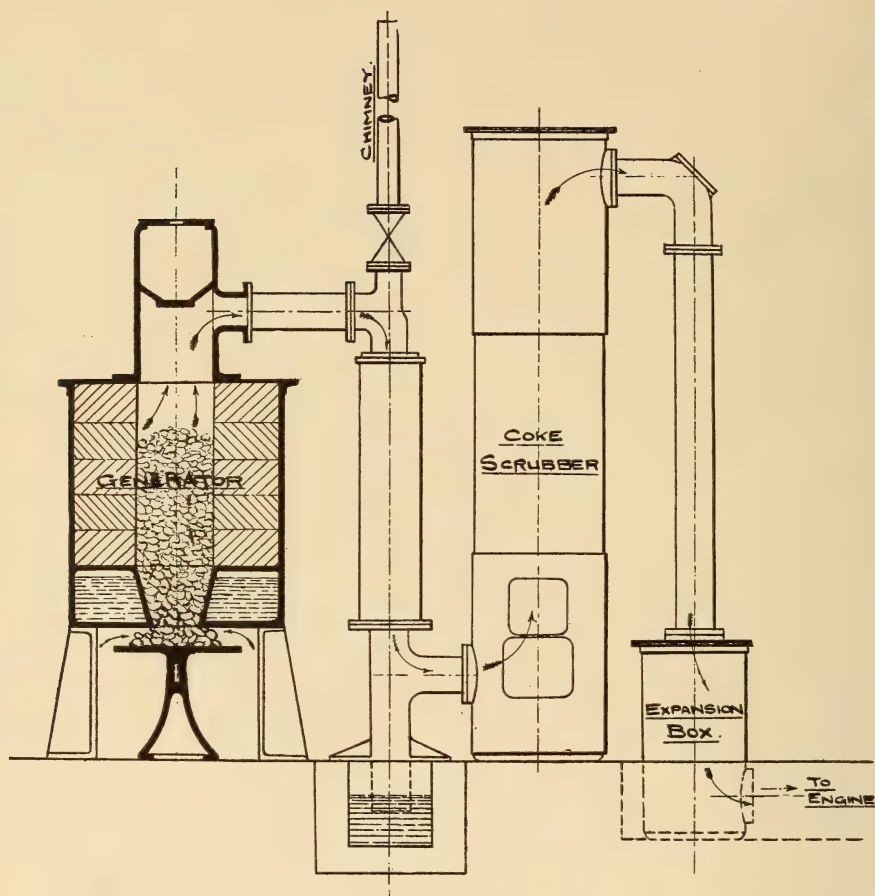


FIG. 13.—DIAGRAMMATIC SECTION OF CAMPBELL GAS PRODUCER

smaller gas engine of from 25 to 30 horse-power. The two larger engines were regularly shown in motion, and were supplied with gas from the makers' own suction plant, which was of the open-hearth type. A diagrammatic view of this arrangement of suction producer is shown in Fig. 13, and it will be noticed that the ordinary firebars and closed ashpits are dispensed with and the column of fuel is supported on a deadplate, which is mounted on a small bogey for convenience of removal. The evaporator is placed at the base of the producer and surrounds the zone of combustion, where it is most effective in producing the maximum amount of steam and, at the same time, preventing the formation of ad-

hesive clinker. Air enters between the deadplate and the open bottom of the producer, and the steam is introduced at the same place. The gas flows away from the producer just below the charging hopper and passes down a vertical scrubber with a water-seal at the bottom, and then up through coke scrubbers through an expansion box on its way to the engine. The separator has an outer jacket, through which the water passes before entering the evaporator, and the bulk of the heavy particles which come over is caught in the water-seal at the bottom before reaching the scrubbers. The producer is started up by the ordinary hand-driven fan in the usual manner, and, owing to facilities for cleaning

and clinkering, can be kept at work continuously over long periods. The producer shown at Brussels had a normal capacity of 200 horse-power, but they are built in standard sizes up to 575 horse-power, rated on the basis of using coke of 12,600 B. T. U.'s per pound. It is claimed that it will work with coke breeze, anthracite refuse, and even the smoke dust from locomotives, and, while it is not intended for use with bituminous fuels, it will deal with almost any non-caking refuse fuel. The four-cylinder vertical engine illustrated in Fig. 14 was designed for a maximum load of 150 horse-power on producer gas of 135 B. T. U. net value, and ran at 300 revolutions per minute. This type is suitable for driving dynamos coupled direct. The first vertical engine of this design of any

size was supplied as long ago as 1904 and was of 350 horse-power, and since then quite a number have come into use in lighting and power stations and for driving large centrifugal pumps directly coupled. These engines were built with two cylinders to give from 50 to 120 horse-power, and with four cylinders to give from 100 to 500 horse-power, working under normal conditions. The illustration to a large extent explains itself. It is so designed that each line of cylinders is practically independent of the other. The inlet valves seen on the top of the engine are clear of the cylinder covers, and are placed in plugs, which are readily removable. In the particular engine shown both the inlet and exhaust valves were worked by push rods from a camshaft placed in the base, and the

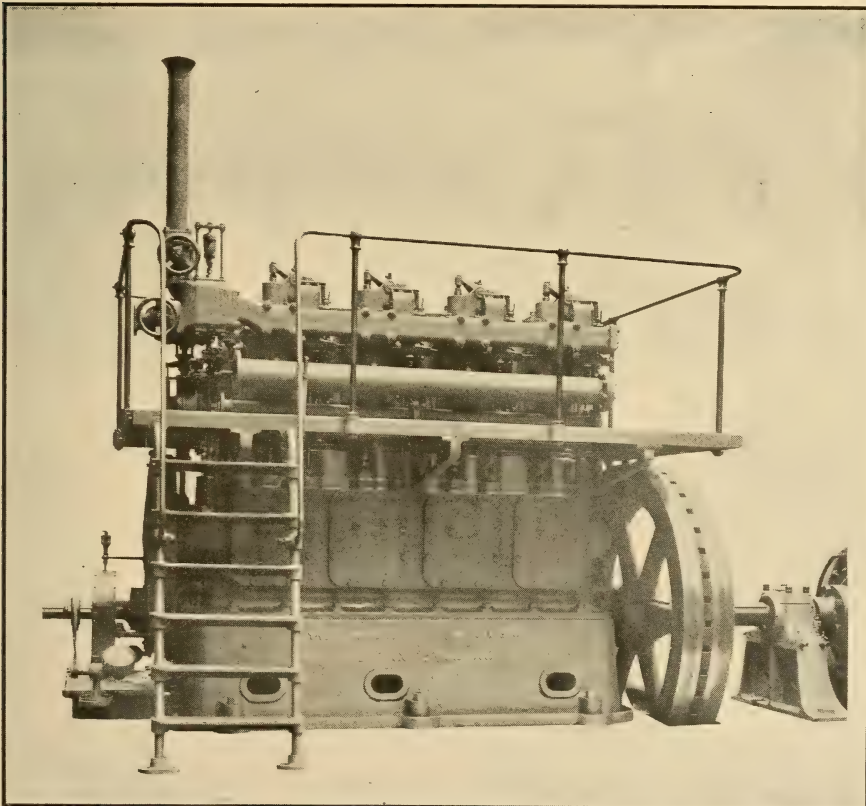


FIG. 14.—VERTICAL CAMPBELL GAS ENGINE

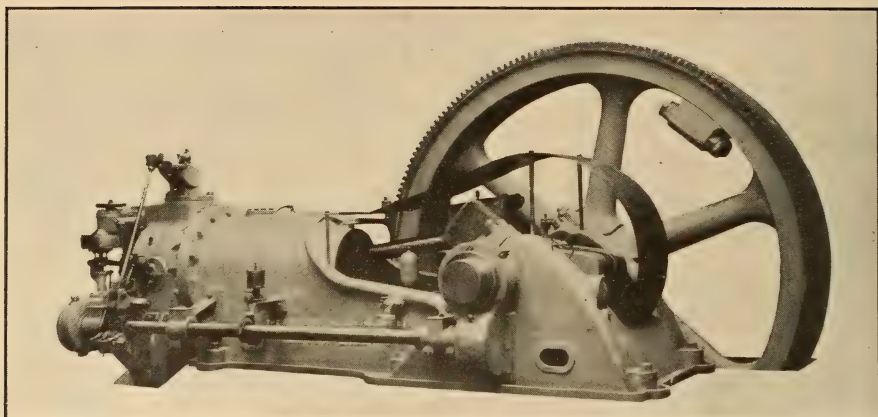


FIG. 15.—HORIZONTAL CAMPBELL GAS ENGINE

bearings for the camshaft and crankshaft are machined out simultaneously at one setting. The governor is driven by independent gearing from the crankshaft, and each cylinder has its own separate magneto and ignition gear. Forced lubrication is obtained by means of valveless pumps, and starting is effected by compressed air obtained from a small, independent compressor. Both the crankshaft and the connecting-rod are made of Siemens-Martin steel of the same specifications as is required by the British standard specifications for locomotive crank axles.

The horizontal engine of 120 brake-horse-power, as illustrated in Fig. 15, attracted a good deal of attention amongst the experts on account of the extreme simplicity of the governing arrangements. In this case a centrifugal governor merely controls a freely-moving throttle valve in the gas inlet, and the regulation is variable-quality governing pure and simple. This system, at all events, ensures sufficient air for complete combustion, and, as will be seen from the inspection of the accompanying diagram in Fig. 16, an almost constant compression is maintained under varying loads. The argument that at no load the charge would become too weak to be fired does not seem to be borne out in practice, and, as these engines have magneto ignition

with a variable timing device, any tendency in this direction can be, to a certain extent, compensated for. One little structural peculiarity of this engine was pointed out by the makers, and that is, instead of the small end of the connecting-rod working on a pin carried in the trunk, the gudgeon pin itself is shrunk into the connecting-rod and works in two adjustable bearings in the trunk piston.

A horizontal suction gas engine of about 20 horse-power was also exhibited by the same makers. This

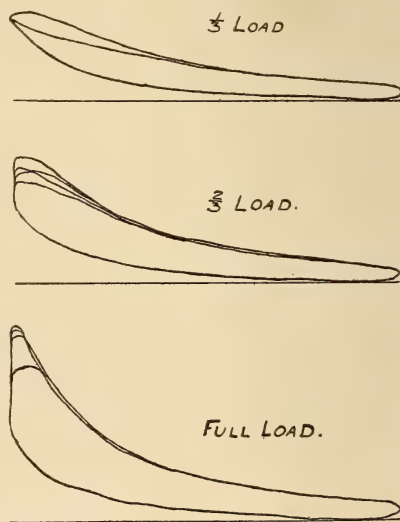


FIG. 16.—DIAGRAMS FROM HORIZONTAL CAMPBELL GAS ENGINE

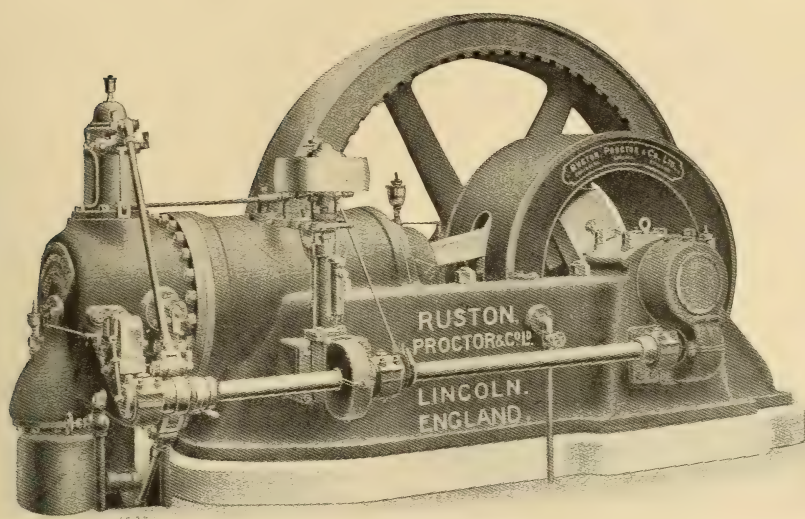


FIG. 17.—RUSTON-PROCTOR 75-HORSE-POWER ENGINE

was arranged for hit-and-miss governing. They had also an interesting oil engine, which will be referred to later on, and showed a small compressor for starting purposes. The collective exhibit was awarded a Grand Prize by the international jury.

Messrs. Marshalls, of Gainsborough, showed, for the first time, a horizontal gas engine; but, as they have not yet standardized the type, they prefer not to publish any details.

Fig. 17 shows a 75 brake-horse-power engine exhibited by Messrs. Ruston, Proctor & Co., of Lincoln, and was fitted with a single flywheel and outer bearing, and drove the other machinery about the stand by a belt pulley, gas being supplied by one of the same firm's suction gas producers. This had a vertical, water-sealed ashpit and was fitted with removable firebars, and the capacity of the furnace chamber was made sufficiently ample to be capable of dealing with inferior fuels. The cleaning doors at the bottom of the producers were fitted with a patent quick-closing device, and a rather neat arrangement of three-way cock was introduced into the down-comer

pipe leading from the top of the producer to the base of the scrubber. This was to prevent any gas leaking back into the producer when the plant was standing, as, when the attendant opens the vent to the atmosphere, he at the same time shuts off communication between the scrubber and the producer. The engine exhibited was what the makers term their "GN" size, and was designed to develop 75 brake-horse-power at 185 revolutions per minute when burning Welsh anthracite having a calorific value of 14,500 B. T. U. per pound; but an inferior quality of fuel—namely, Belgian anthracite—costing only 12 francs per ton delivered to the exhibition, was being actually used.

The general appearance of the engine is shown in the illustration, and, while the specification does not differ much from that of other good makers, it is obvious that the details have been very carefully considered, and the workmanship is excellent; indeed, it may be remarked that the fit and finish of all the gas engines shown were very good, the builders apparently making it a point of honour not

to finish or polish up their engines specially for show purposes.

In this engine particular attention seems to have been given to the mechanical lubrication of all moving parts, duplicate lubrication for the crank-pin being provided and forced lubrication to the cylinder. The ignition magnetos were constructed with specially enclosed magnets, and were in duplicate, being fitted with an adjustable timing device; but the chief feature of novelty was the variable admission gear shown in Fig. 18. It will be seen that the gas valve *D* is on the same spindle as the inlet valve, but has a certain amount of lap, so that the air enters the combustion chamber in advance of the gas and thus has a scavenging effect, and, as the gas valve also closes before the inlet valve, no gas is left in the mix-

ing chamber. The regulation depends upon the amount of mixture admitted, and, as will be seen from the diagram, this is controlled by a Hartung governor, varying the position of a floating roller *C*, which is interposed between the plunger forming the upper guide of the valve spindle and the under side of a rocking lever *B*, which derives motion from the camshaft through the rod *A*. As the speed rises, the governor moves the roller *C* nearer to the fulcrum of the lever *B*, causing a diminishing opening of the valve, and, consequently, admitting a reduced charge.

As the speed falls the reverse action takes place. It would seem that this gear is very similar to that used on the National engine, and also the German engine of Schmidt, but it dispenses

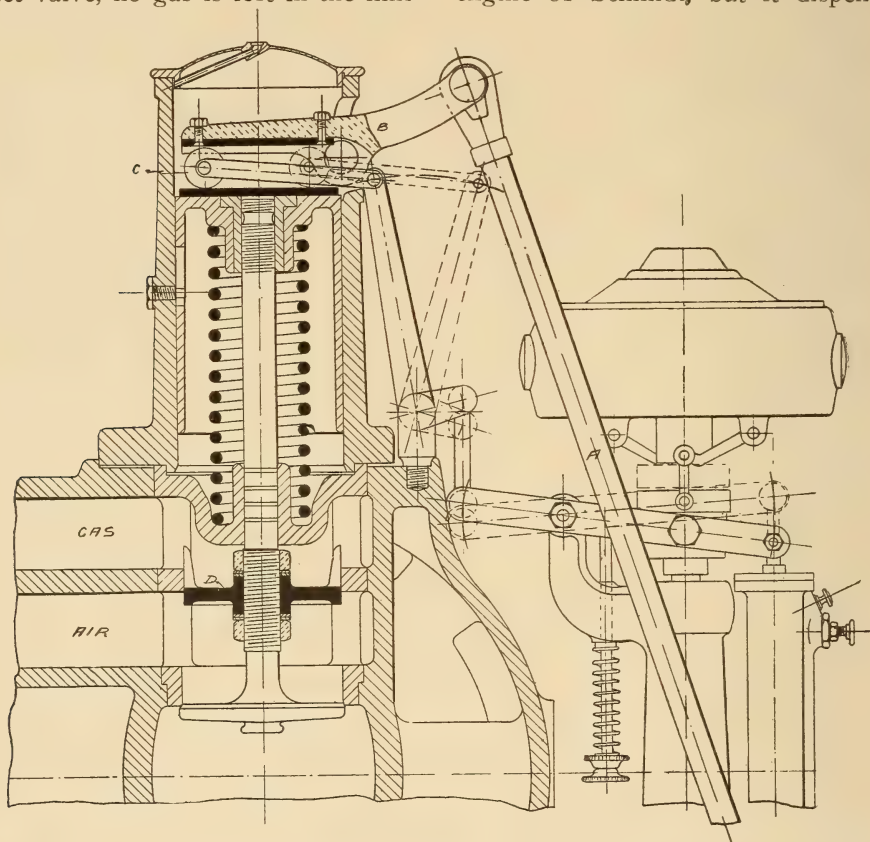


FIG. 18.—VALVE GEAR OF RUSTON-PROCTOR 75-HORSE-POWER ENGINE

with the use of one rocking lever.

No large gas producers of the pressure type were shown at Brussels, but the Power Gas Corporation, of Stockton-on-Tees, exhibited a small model of a Mond gas plant arranged for ammonia recovery. This illustrated the new arrangement in which horizontal washers take the place of the vertical acid, gas and air-heating towers. This modification has rendered it possible to reduce materially the first cost of the plant, and has, at the same time, got over the former trouble due to the choking up of the ring tiles in the vertical towers. Up to the present the question of ammonia recovery in connection with producers burning low-class bituminous fuels seems to have attracted but little attention on the Continent; but, since it has been discovered that a very high ammonia recovery can be obtained from peat, it is probable that much more will be heard of the several systems now before the public.

The writer has left the mention of the Humphrey pump to the last, and, in consequence, there is but little space to do justice to this most important exhibit. The Pompe-Humphrey was undoubtedly the most novel and spectacular exhibit in the machinery department, and attracted crowds of people to watch this apparently inert combination of pipes circulating a discharge of between four and five tons of water per minute. The pump was designed to lift 250,000 gallons of water per hour to a height of 150 feet, and was on exhibition about six hours a day. The general appearance of the pump is shown in Fig. 19, reproduced from a photograph, and the diagrammatic view of the layout is shown in Fig. 20, except that the pipe connections in the diagram are reversed to what they were at the exhibition. The pump is of the simple type, and is of the same design as the original one first put up at Dudley Port. Beyond the moving column of water the only working parts about this

pump are the inlet, exhaust and scavenging valves, with a timing device for the ignition. Although the pump operated on a four-stroke cycle, the cycle differed from the Otto cycle used on a reciprocating gas engine; but, as this has been so fully explained in the paper which Mr. Humphrey read before the Institution of Mechanical Engineers and in another very interesting paper read by the same author at the Manchester Association of Engineers on November 12, it is best to refer to these communications for a full explanation of the mechanical details. In the very short space of time since this simple pump was perfected the inventor has so far amplified the idea that he can now construct two-cycle pumps, double-barrel pumps and suction pumps, and has also designed a modification of the pump which seems likely to make a valuable air compressor.

The use of the Humphrey pump for the production of motive power is being experimented with by one of the most eminent firms on the Continent, and the practical results they obtain from a 1,000 horse-power engine now under construction will be keenly waited for by all power-plant engineers. The method of obtaining motive power is, of course, to use the gas pump to lift water against an artificial head and drive a turbine or impulse wheel coupled to a dynamo or transmitting power through some form of gearing. Any good type of Francis water turbine may be relied upon to give over 80 per cent. efficiency, and, as a matter of fact, the loss would probably not reach 20 per cent.; but, even if it did, the saving of attention, the economy in oil, and the extreme simplicity of the combined plant would, from a commercial point of view, probably outweigh this, and the simplicity of the whole apparatus would relieve to an enormous extent the responsibilities of the central-station engineer. This pump was given an award under one class as a motive-power engine, and

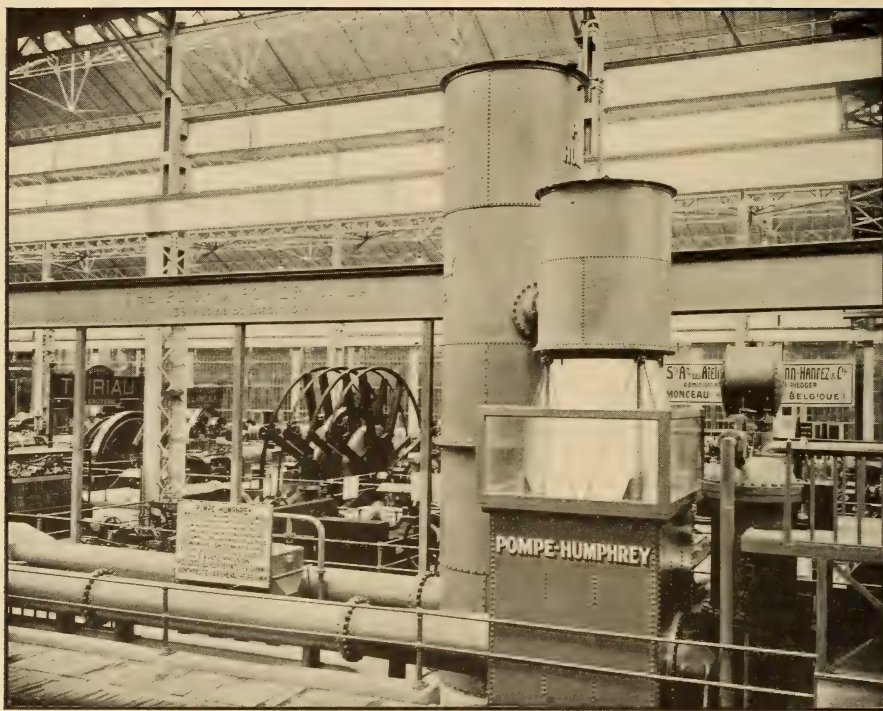


FIG. 19.—GENERAL VIEW OF HUMPHREY PUMP

in the other class as a pump for raising water.

Apart from this radical departure in internal-combustion engines, the progress that has been made in gas engines generally since the Paris Exhibition of 1900 may be summarized as follows:

The single-cylinder, open-trunk, 600 horse-power engine shown at Paris has developed into 5,000 horse-power engines built with four cylinders of the double-acting, closed type, but still working on the Otto cycle. These large engines have been adopted by the majority of the Continental iron and steel works to utilize their waste gases from blast furnaces and coke ovens, and a very large monetary saving has been got therefrom. In England the progress has not been so rapid; but, on the other hand, ammonia-recovery plants worked in connection with producers on a large scale have been put up in quite a large number of instances.

The two-cycle engine introduced by Körting about ten years ago has been pushed in large sizes by one or two German makers, and in England by Messrs. Mather & Platt, who, while retaining the idea, have practically remodeled the engine.

The vertical gas engine has received more attention in England than anywhere else, and they are now regularly built up to 1,000 horse-power, and in all probability will be constructed in still larger sizes.

Although the thermal efficiency of the gas engine has not been much improved during the past ten years, the mechanical efficiency of the machine has been considerably increased, owing to the simplification of the design and elimination of surplus parts.

All makers have devoted close attention to the simplification of the valve gear and governing arrangements, and a large gas engine has no more complications about it now than a large steam engine. Further, the

ignition devices have been greatly improved.

The suction gas producers shown at Brussels represent a branch of the business that has grown very largely during the past few years, and, although in the writer's opinion a pressure producer is a more manageable arrangement in larger sizes, say above 500 horse-power, there is no doubt that there are now an enormous number of suction producers at work satisfactorily making gas from most diverse fuels, such as small coal, lignite, shavings, sawdust, spent tan—in fact, from almost anything that contains a reasonable amount of combustible.

The problem of using bituminous fuel in a suction producer has been met in two ways; firstly, by using the producer of ample capacity with the grate so arranged that the clinker does not readily close on the bars,

and, at the same time, taking the gas out of the tar by an external tar extractor and sawdust scrubbing; and in the second case the same end is attained by using a down-draught producer in which the whole or a portion of the gas is made to pass back again through the zone of combustion, thus destroying the tar in the producer itself.

The Crossley producer exhibited was an example of the first system, and the Mason, Emerson Dowson and Morton are well-known British examples of the down-draught class, but none of these was actually shown at Brussels.

Nothing in the nature of an internal-combustion turbine was exhibited at Brussels, although it is well known that considerable progress has been made in this direction in a quiet way by the experimenters in Paris.

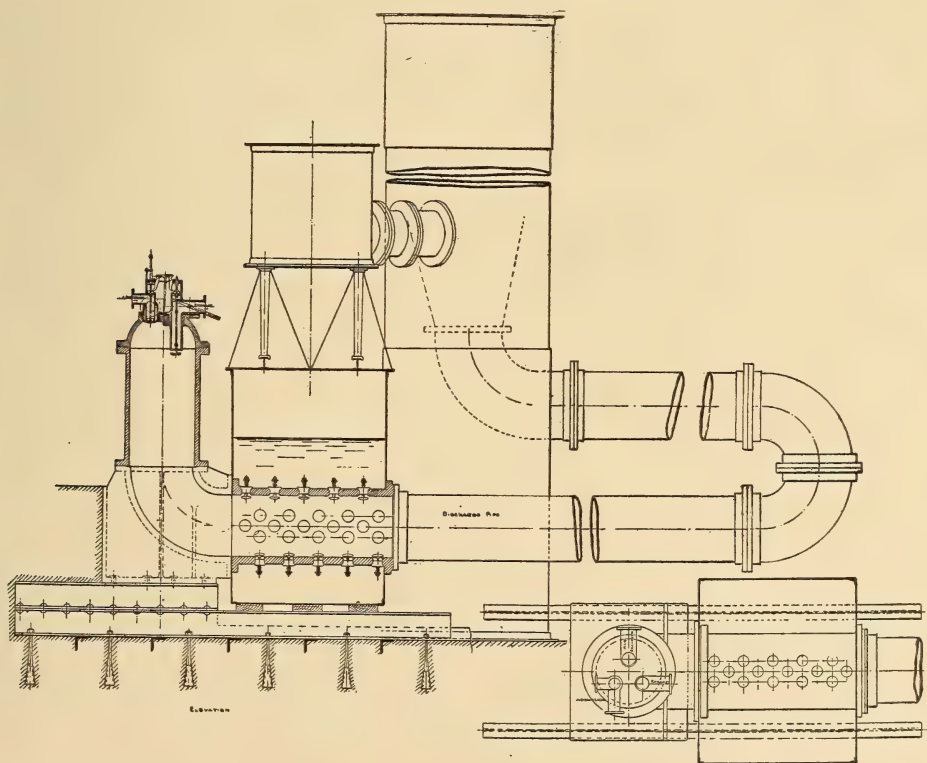


FIG. 20.—DIAGRAMMATIC VIEW OF HUMPHREY PUMP

A great deal has been done during the past ten years in the development of the reciprocating gas engine, and more will doubtless be done in future, but its limitations are pretty well realized.

With regard to the development of the idea contained in the Humphrey pump, it is yet premature to predict how far this will affect the produc-

tion of motive power on a large scale.

However, it may be fairly stated that the Brussels Exhibition will have the distinction of having introduced to public attention an invention that may have an even more far-reaching influence than the exhibition of the first large gas engine at Paris, which was at the time regarded as an epoch-making event.

METHODS OF DETERMINING AEROPLANE ALTITUDES

By Henry Harrison Suplee

MEASUREMENTS of altitude are usually more difficult of precise determination than those made at or near the surface of a comparatively level country. This is evident in connection with the frequent revisions which have to be made of the altitudes of mountain peaks, and it becomes especially apparent when the true height attained by an aeroplane is to be determined.

The early performances of flying machines were comparatively limited, so far as altitude was concerned, the height above the surface being little more than was necessary to insure safe clearance above trees, buildings and similar obstructions. It is only within the past year that altitudes of several thousand feet have been attained; but since the aviators have succeeded in acquiring greater control over their machines, and have themselves discovered that no serious difficulty attends the conduct of flights in the upper air, there has arisen a competition among sporting airmen to secure the "record" altitude, which demands some reliable method for measurement of the true position above the surface of the earth. Apart from the desirability of determining the correct height attained in any such competition, it is also extremely important to be able to measure the correct position of an enemy in the air as soon as the aeroplane enters the domain of warfare. The range must be obtained if the special aerial guns are to do effective work, while knowledge of the true altitude is also most desirable in connection with the work of the scouting aviator.

Several requirements must be met in considering satisfactory solutions

of the problems connected with aerial altitude measurements. Broadly, two fundamental methods have to be considered: one in which the apparatus employed is carried in the aeroplane itself, the other in which the measurements are made by the use of instruments observing the flying machine from the ground. These, again, may be divided into methods which enable the altitude to be determined immediately and continuously, and those which require subsequent computations to be made from the observed data.

The older aeronauts usually depended upon the barometer as an indicator of altitude, and with the sustaining power of a large balloon and the opportunity afforded of consulting such an instrument carefully a certain degree of precision was obtained, especially when a high-grade mercurial barometer was carried, and simultaneous readings were taken on the surface of the earth. Even with a carefully calibrated aneroid, compared with a standard instrument immediately before and after the trip, the altitude attained might be fairly well determined, provided the rate of ascent and descent of the balloon was not too rapid.

In the case of the aeroplane, however, the conditions render it impracticable to use a mercurial barometer, while the demands upon the operator's attention preclude the possibility of visual readings and records. Reliance, therefore, has to be placed upon the recording aneroid barometer, similar in general construction to the instruments generally employed for meteorological purposes, and it is by such apparatus that most of the pub-

lished altitudes attained by aeroplanes have been determined.

Records of this kind, however, must be accepted with caution, and should be carefully checked, whenever possible, because the conditions under which the instruments are obliged to act are hardly conducive to a very high degree of precision.

A brief examination of the construction and action of the aneroid barometer will show why this is so. The aneroid barometer is really a special form of pressure gauge, intended to measure external pressures generally less than the ordinary atmospheric pressure at sea level. The pressure gauge, as usually employed in engineering work, is employed to determine pressures maintained in closed vessels, such as steam boilers, reservoirs of compressed air, or of water under pressure, and the like, and it is not difficult to make suitable connection and lead the pressure fluid into some kind of a closed chamber in the instrument and utilize the dilatation or other movement of the walls of the chamber to indicate the variations in pressure. In the case of the barometer, however, the pressure fluid is the external air, and the arrangement of parts must be practically reversed. This is effected by employing a small chamber, usually cylindrical in form, somewhat like a short drum, the top and bottom being corrugated in order to permit a certain amount of movement. If the air be exhausted from such a chamber the tendency will be for these corrugated ends to collapse together under the external pressure of the air, and if this tendency is opposed by a spring of sufficient strength to hold the ends apart, the apparatus will be in equilibrium so long as the pressure of the external atmosphere remains constant. If the external pressure increases, the corrugated ends will move together, while if the pressure decreases the force of the spring will pull them further apart. The combination, therefore, will respond at all times to the variations

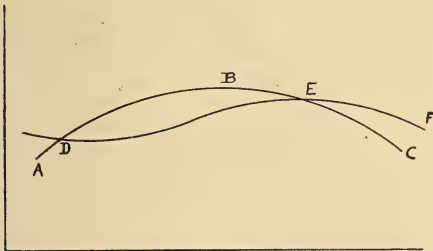
in atmospheric pressure. It is evident that the amount of movement permissible is limited by the elasticity of the metal and by constructive details, and that it is in all cases very small.

It is necessary, therefore, to use some method of multiplying the motion in the "vacuum box," as it is termed. In the ordinary dial barometers of the Naudet type this multiplication of motion is effected by the combination of levers and of watch-chain, often visible through the opening in the front, while in the recording barometers of the Richard design recourse is had to the use of several vacuum boxes built up together in such a manner as to secure the accumulated movement of all, this increased movement being also multiplied by leverage. A pencil attached to the end of the lever enables the vertical movement to be recorded upon ruled paper, and if this paper is kept in motion at right angles to the pencil movement by means of clockwork a curve of pressures will be automatically described. It is an instrument of the latter type which has been used in most of the recent altitude flights of aeroplanes.

The great difficulty in obtaining reliable records with such a barometer lies in what may be termed its "lag." As will be perceived from its construction, a certain amount of *time* is required for the mechanism to respond to changes in external pressure. This lag is due not only to the movement of the vacuum box itself, but also to the frictional resistance and inertia of the multiplying mechanism—and, indeed, it is principally caused by the latter. The result is that the instrument does not respond quickly enough to follow rapid changes in altitude. This may readily be demonstrated by carrying an aneroid barometer in the hand while making a rapid ascent in the express elevator of a tall building. The pointer will be seen to fall for some little time after the elevator has reached the top of its run, showing

that an immediate reading would have been erroneous. In mountain ascents and similar measurements this error is eliminated by giving sufficient time for the instrument to catch up with the pressure changes, and under such conditions very precise altitude determinations may be made, but this is impracticable in the case of the aeroplane.

The extent to which this lag may



CURVES SHOWING LAG OF BAROGRAPH RECORD

affect the indications of a recording aneroid barometer is seen in the diagram. If the curve *A, B, C* indicates the actual pressures of the atmosphere and the transition be rapid, the recording barometer, which may be correct at the point *D*, will not rise quickly enough to trace the true curve, and will still be rising when the correct curve has begun to fall, so that the record on the paper of the instrument will be something like *D, E, F*, different both in form and position from what it should be. Such a deviation from the truth will be greater or less, according to the rapidity in the change of altitude. In general, it may be accepted that the recording barometer as at present constructed may show the correct height of the aeroplane by which it is carried if the machine soars at a fairly constant height for a moderate time—probably half an hour would be ample—but that under more rapid altitude changes it will indicate a lower altitude than the true one.

In any case, it is impracticable to obtain a reliable determination by the direct reading of the instrument alone. The reading should always be

compared with that of a similar instrument which has been on the surface of the earth beneath the aeroplane, and each point on the curve should be compared with the portion of the surface curve made at the same moment of time. The dial of an aneroid barometer placed before the face of an aviator will give him some idea of his altitude, and show him whether he is ascending or descending. But it cannot be depended on to give positive and immediate information about his altitude; this must be determined after the descent and comparison with the station barometer.

It is true that there are certain types of aneroid barometers, notably the improved instruments of the Goldschmidt pattern, which are notably free from lag, owing to the direct connection between the vacuum box and the indicating arm; but these instruments have, as yet, not been made in the recording form, and require careful and precise ocular readings to be taken and the altitude subsequently computed. While especially well adapted for mountain service and for the measurement of altitude determinations upon the surface of the earth, they have not, as yet, been adapted to aeronautical purposes. It is probable that a barograph, combining the accurate indications of the Goldschmidt barometer and the convenience of the well-known disc recording pressure gauge, may be constructed for this purpose.

The suspension of a barograph when carried in an aeroplane is a matter which demands attention. Vibrations, in themselves, are rather beneficial than otherwise in the use of an aneroid barometer, and it is desirable that the ordinary instrument should be tapped before a reading is taken, in order that the frictional resistance of the pivots and other working parts may be overcome. The continual trembling of the aeroplane motor, however, introduces vibrations into the record curve, which may become periodical and ex-



PHOTOGRAPH OF ISLE ST. LOUIS, TAKEN FROM BALLOON

The known distance between river banks and the known focus of lens enable altitude to be computed

cessive unless the instrument is carefully suspended. M. Latham suspends his barometer from his neck, but a better plan is that devised many years ago by the late Col. Renard, the case of the barograph being placed within a bamboo cage and held suspended in space by a number of rubber bands. It has been shown that an instrument thus suspended may be allowed to drop from a height of 10 or 15 feet to the ground without injury. Barographs fitted in this manner have been successfully used upon the *ballons-sondes*, or free exploration balloons, sent out for meteorological investigations.

Optical methods, employed from the aeroplane itself, are necessarily limited, since they usually demand more attention than can be given by the operator himself, and require the service of an independent passenger. The principle is that of the well-known artillery range-finder, the observer *N* in the aeroplane sighting upon two points, *A* and *B*, on the ground, and reading the correspond-

ing distance ($a-b$) on the scale of the instrument, whence the proportionality of similar triangles gives the altitude; or the scale of the instrument may be so graduated as to enable the altitude to be read directly.

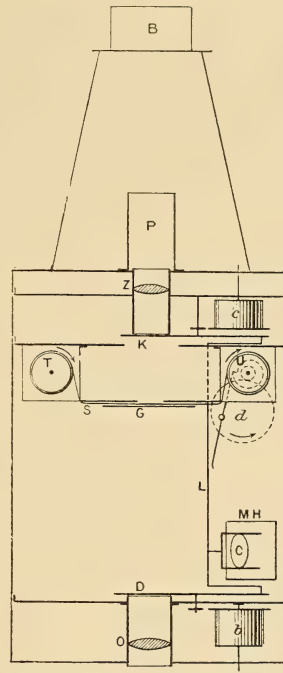
This principle, however, may be still further extended by the use of the apparatus already fully developed for the operations of "photogrammetry," or photographic surveying.

The idea of taking photographs from a balloon appears to have originated with Nadar as long ago as 1855, but it was not until the perfection of the gelatino-bromide dry plate, and the consequent possibilities of instantaneous photography, that practical results were obtained. Attempts were made in France, in 1878 by Dagron and by Triboulet, and in 1880 by Desmarests, while in 1883 some very successful photographs were taken in England by Shadbolt. Photography from balloons thus became recognized as a valuable adjunct, especially in connection with military observations, and its possi-

bilities have by no means yet been exhausted.

The excellent work which has been done by French topographers, notably by Col. A. Laussedat, using cameras of special design, arranged so as to enable several correct perspective views to be combined into a single topographical map, shows what may be done when a direct plan can be photographed from above. Already the camera has been arranged to permit photographs to be taken from observation kites, and a similar apparatus is adaptable to the aeroplane.

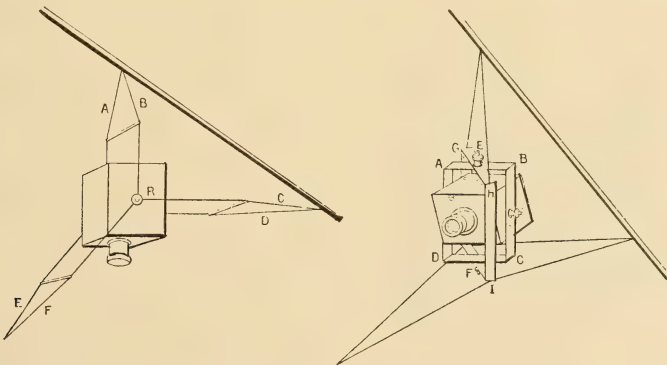
By having a ruled screen placed within the instrument so that the lines are photographed upon the film at the same time as the surface of the earth beneath, the scale of the picture may readily be determined in connection with the known focal length of the lens, and thus the only element required to be known is the true dimensions of some object in the picture. In the case of altitude record trials the use of certain clearly marked monuments on the field furnishes the necessary information, and the proportion between the true distance between two stripes on the field and their distance on the photograph will give the relation between the focus of the lens and its height above the ground. When no predetermined base is visible it may still be possible to find out subsequently the dimensions of some building or other object in the picture, and thus



ARRANGEMENT OF GAUMONT CAMERA

The two lenses *O* and *Z* photograph the images of the view beneath and the barometer *B*, upon the film *G*, by means of the two shutters *b* and *c*.

enable the altitude to be computed. Several years ago M. Gaumont devised an ingenious combination of camera and aneroid barometer, so arranged that the dial of the barometer was photographed upon each picture, thus furnishing a record of the altitude at which each negative was taken. This method involves the gen-



METHODS OF SUSPENSION OF CAMERA FROM AEROPLANE

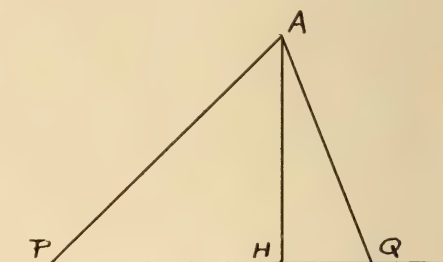
eral objections to the use of the aneroid which have already been mentioned, but the plan has wide possibilities in connection with probable improvements in barometers for this purpose.

An ingenious plan which has been suggested for measuring the altitude of an aeroplane, and which, while it requires the services of an independent operator, demands no other apparatus than an accurate stop-watch, is the acoustic method. Any sharp sound, such as a quick whistle, or report which may be differentiated from the noise of the machine itself, will be returned to the ear of the operator in the form of an echo from the surface of the earth. If, therefore, the time elapsing between the sound and the echo be noted, the corresponding distance may be estimated from the known velocity of sound. Taking the velocity of sound at 1,100 feet per second, or a little more than 100 feet for a tenth of a second, and remembering that it is the double distance, going and returning, which is thus computed, the error of observation would be between 50 and 60 feet for one-tenth of a second. This method is also liable to variations,

due to differences of temperature and of layers of variable density in the atmosphere, and is more available for a quiet balloon than for a noisy aeroplane.

In the second kind of observation, those made from the surface of the earth, the operations are similar to those used in the ordinary trigonometrical determination of heights.

Thus, if an aeroplane be situated at A , and two observers at P and Q , at the extremities of a base line of known length, and simultaneous observations are made of the angles APQ and AQP , the triangle will be completely determined, and the



TRIANGULATION METHOD FOR DETERMINATION OF ALTITUDE

height AH may be computed. If the observers are directly beneath the aeroplane, the altitude will be obtained very simply, but this is rarely the case. It will, therefore, usually be necessary to make three simultaneous observations from as many known points, from which the true height may be obtained.

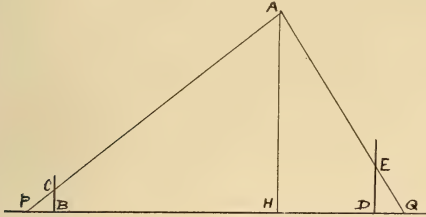
At the Harvard-Boston Aero Meet in September, 1910, trigonometric measurements were made with a base line of somewhat more than 6,000 feet. The operators were provided with standardized watches, to enable tally to be kept of the observations, and with head and breast-attached telephones, to enable the word to be passed for the moment of the simultaneous observations. Since transit instruments were employed, it was possible to measure both vertical and horizontal angles, and thus the results were obtained with but two observing stations. For



PHOTOGRAPH TAKEN IN GAUMONT CAMERA, SHOWING BAROMETER DIAL UPON VIEW

ordinary angular measurements of this sort the sextant has also been employed, but the precision is necessarily lower than with the transit.

Another method, suggested by Commandant Paul Renard, may be applied under certain conditions.



RENARD'S METHOD FOR DETERMINING AEROPLANE ALTITUDES

Two observers are placed at points P and Q , the distance $P-Q$ between them being known, and it also being known that the flight of the aeroplane will pass over some point vertically over the line between P and Q . The two observers are furnished with instruments which enable them to measure the apparent height. In the absence of sextants, or other instruments of precision, a simple substitute may be found in the form of rods placed at B and D , these being erected as nearly vertical as possible and at points at which the distances $B-P$ and $D-Q$ are known. These rods should be graduated so distinctly as to be easily read by the observers, and it is essential that PB and DQ should be on the same alignment. The observers are to be instructed to watch for the passage of the aeroplane and to read the apparent point at which it crosses the graduated rods at the moment when it passes over the base line. With these readings and the knowledge of the distance between the two observers, the altitude of the aeroplane may be computed as follows:

From the two sets of right-angled triangles we have

$$\frac{PB}{CB} = \frac{PH}{AH}$$

and also

$$\frac{QD}{ED} = \frac{QH}{AH}$$

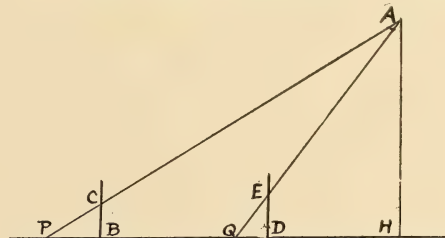
By adding these two equations together we get

$$\frac{PB}{CB} + \frac{QD}{ED} = \frac{PH + QH}{AH} = \frac{PQ}{AH}$$

In this formula we have the quantities PB , QD and PQ , already known, while the single unknown, which may thus be determined, is the altitude AH . This method, it will be observed, is independent of the particular values of the horizontal distances HP and HQ —that is, the aeroplane may pass anywhere over the line between the two observers, provided the corresponding readings on the two graduated rods are correctly taken. It is desirable, however, that the aeroplane pass between the observers, although readings may be taken if it should pass beyond them, as shown in the figure. With experienced observers this will give fairly good results, since the men will secure approximately simultaneous readings. The principal defect is that it gives the height over some undetermined point H , and hence it is well, if possible, to have the whole system arranged upon a fairly level plain.

When a trial for an altitude record is made upon this plan, the aeroplane may circle above the base line and its height taken every time it cuts across the line, the observations being numbered, to enable the proper ones to be paired.

In many cases, especially in war-



RENARD'S METHOD WHEN AEROPLANE PASSES BEYOND OBSERVERS

fare, it is the distance between the observer on the earth and the machine in the air which is desired. This is really a problem in range-finding, and the principles are well known.

At the camp of Chalons the Souchier telemeter was used with a fair measure of success. The instrument consists of two telescopes, of which the objectives are fixed at one metre apart and the images brought together by reflectors, so that measurement is made of a very acute triangle, the aeroplane being at the sharp apex opposite the base of one metre.

It will be seen that at the present time there is no method which is entirely satisfactory for general use. Trigonometrical observations from the ground, while the most accurate, require much previous preparation, practicable only during some exhibition or sporting event, and, possibly, capable of permanent installation in important fortresses liable to attack, but otherwise inapplicable for lack of

time and need of suitable apparatus.

The photographic methods require, in general, the services of an additional operator, although it is possible that an automatic device may be produced. In any case, it does not furnish its report until after the flight is over and the film developed, and hence its usefulness is limited to the production of a subsequent record of the trip. It may well be investigated, however, in connection with the substantiation and verification of altitude records made by other methods.

There remains the barometrical method, and, while this is at present lacking in precision, it offers the greatest opportunities for improvement and development. In view of the high degree of precision attained in the determination of mountain altitudes by aneroid barometers of the Goldschmidt type, it seems altogether possible that some improved variety of barograph will be produced in response to the demand which the aeroplane is making.

THE RAILWAYS OF BRAZIL

By Lionel Wiener

XI.—THE MOGYANA SYSTEM—THE SOROCANABA BRANCH OF THE BRAZIL RAILWAY

The present instalment of Mr. Wiener's comprehensive review of the railways of Brazil includes the conclusion of the description of the Mogyana system, which was begun last month, and commences an account of the very important group included in the lines controlled by the Brazil Railway Company.—THE EDITOR.

THE Mogyana Railway lines have been built on the American plan, quickly and cheaply, so as to secure as fast as possible the maximum protected zone.

The metre gauge has been adopted with a regular craze of enthusiasm for its adaptability and cheapness, and the rails were simply laid beyond each other, regardless of the easiest or best route. The radius of the curves was too low, their number too high, the gradients too heavy.

On the Caldas and Itapura lines the radius of curves was 264 feet; on the Silveira 2-foot branch, 165, and 330 on the others; and even this is too little on the main lines, especially when it is so easy to do better.

The gradients on the main line, the Caldas, Monte Alegre, Pinhal and Silveiras branches are 1 in 33; those of the other lines, 1 in 40.

The original cost was low: £4,581 per mile for the 66 miles then open. In 1886 the outlay had further been cut down to £3,599 for the 230 miles. But since 1893 traffic began increasing by leaps and bounds, and everything had to be gone into over again. That year the cost of the mile reached £4,436, and increased until, in 1898, it reached £8,160. This was the penalty of having built too cheaply at the outset; but, on the other hand, the Mogyana now has one of the finest and best-worked systems in Brazil.

The capital expenditure is well over £5,476,180.

Twenty years ago the gross earnings were £802 per mile and the net earnings £323. In 1908 receipts

reached £1,371 per mile and a total of £1,150,171, of which expenses took out 53.8 per cent. Net earnings—12 per cent. of the capital ever since 1885—have been as high as 22 per cent. after the increase in the rates.

As with all Brazilian railway companies, the year 1908 shows a slight falling off on 1907. The following tables show the principal items of expenditure and sources of revenue in 1907 and 1908:

EXPENDITURE.

	1908.	1907.
Traction department.....	£218,337	£251,264
Permanent ways and works.....	156,488	149,324
Traffic department.....	113,519	111,042
Directorate and management.....	15,862	16,258
Campinas station.....	13,830	13,787
Accountants and cashiers.....	20,178	20,567
Telegraph and electrical.....	25,408	23,329
Miscellaneous.....	31,098	39,058

£619,633 £625,641

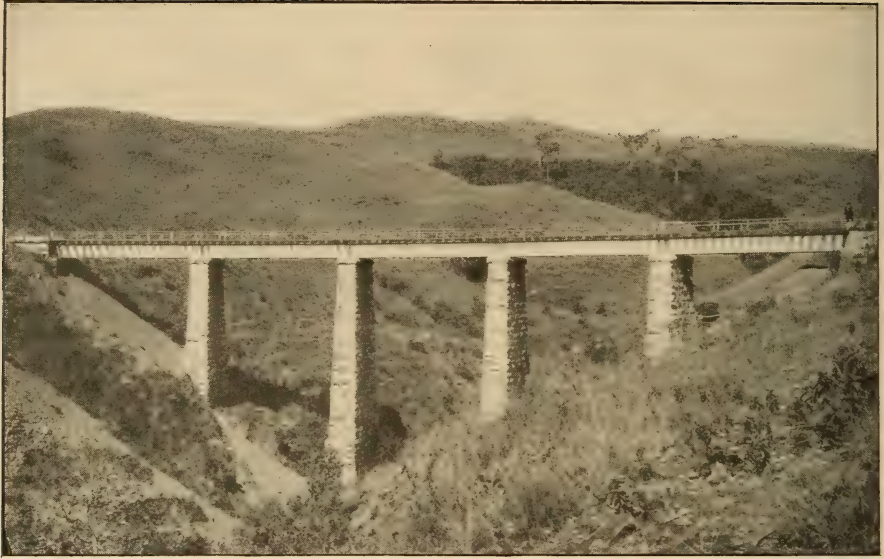
RECEIPTS.

	1908.	1907.
Passengers.....	£152,694	£156,146
Parcels and luggage.....	34,398	30,565
Live stock.....	7,995	9,537
Goods.....	932,427	986,961
Miscellaneous.....	26,824	35,132

£1,154,338 £1,218,341

Coffee, of course, is the principal object of traffic. During 1908 there were carried 286,323 tons of coffee out of a total of 711,073 tons of merchandise. The most important coffee-growing district on the system is Ribeirao Preto, this contributing about 12 per cent. of the total output, and, with Cravinhos and the 15-mile intervening district, it furnishes about one-fifth. Of this, 23,500 tons come from Ribeirao Preto and 27,287 tons additional from the rest of the district.

This coffee—and, in fact, all the coffee of the State—is shipped from



VIADUCT ON THE CALDAS BRANCH OF THE MOGYANA RAILWAY

Santos. About 40 per cent. of the coffee shipped from this port in 1908 came from the area served by the Mogyana system. The following table shows the amount of coffee shipped from Santos during the last nine years, with the percentage carried by the Mogyana Railway. Each sack of coffee weighs 132 pounds:

Year.	Sacks Handled at Santos.	Mogyana's Share.	Mogyana's Percentage.
1900.....	6,518,709	2,738,763	42.01
1901.....	9,594,817	3,946,300	41.13
1902.....	8,808,382	3,294,787	37.40
1903.....	7,875,137	3,265,286	41.46
1904.....	7,150,832	3,126,207	43.74
1905.....	7,028,054	2,990,838	42.27
1906.....	10,960,901	4,085,514	37.27
1907.....	11,316,931	4,252,722	37.57
1908.....	9,249,859	3,684,769	39.83

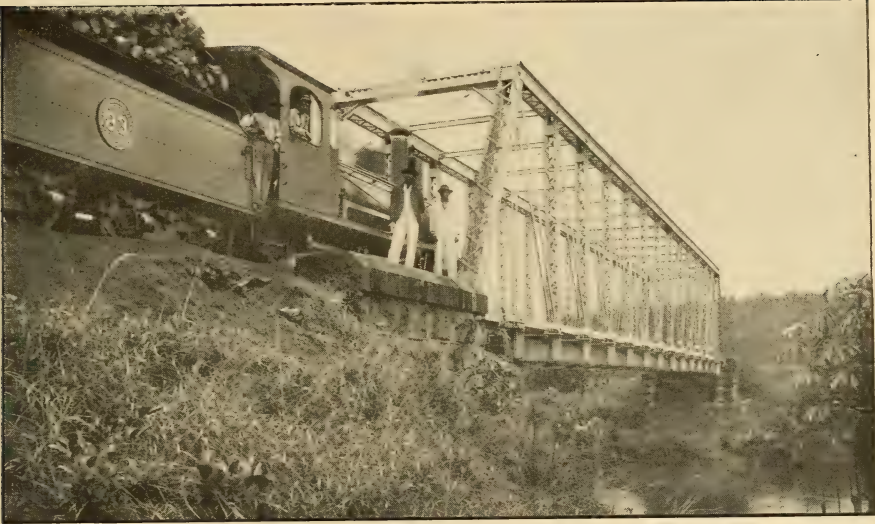
The production of coffee, however, which plays so conspicuous a part in the existence of the Mogyana system, is on the decrease, and, owing to the fall in the price of coffee, coffee rates are also on the decrease.

The Mogyana administration has, therefore, sought elsewhere for something to compensate for this loss, and has found it in rice. Until quite recently all the rice used in Brazil came from abroad; but, owing to the fear that the coffee trade might give out, experiments with rice cultivation

on a large scale have been undertaken. These have proved successful, and the rapid increase in the quantity of rice carried on the railway forms a most interesting feature in its operation. Thus, the amount of rice transported in 1904 was only 128 tons, while in two years it had increased to 3,366 tons, and in 1908 it amounted to 16,535 tons, so that in the short space of five years the traffic in rice was multiplied more than one hundred times. Unfortunately, the carrying of rice is not as remunerative as coffee. A ton of coffee is hauled on an average 122 miles and brings in 38 shillings 10 pence, or 0.38 penny per ton-mile.

Other items of traffic include beans, maize, potatoes, tobacco and hides, totaling about 220,000 tons in 1903 and 259,000 tons in 1908.

Goods earn the greater part of the revenue, but passenger traffic is also important. In 1908 there were carried 1,626,812 passengers, of which about one-fifth were first class, with a total of 40,683,848 passenger miles, an average of 22 miles per passenger. The best train is the North Express, between Campinas and Franca: the carriages are comfortable, but the



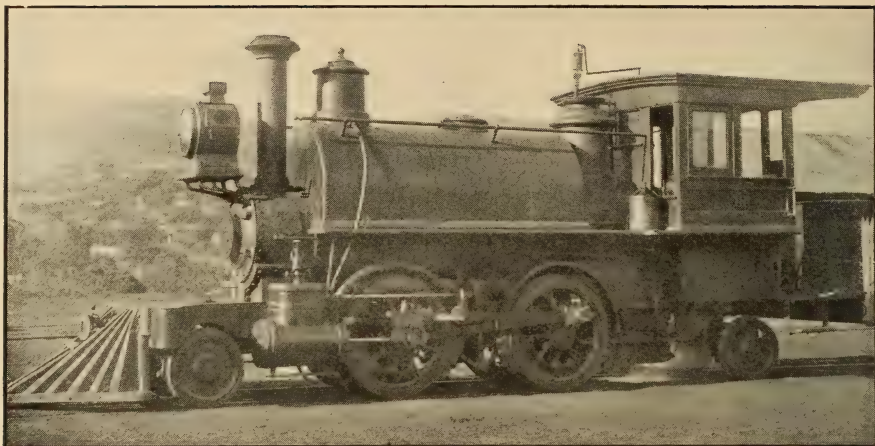
BRIDGE OVER THE SAPUCAHY RIVER. MOGYANA RAILWAY

speed is low, hardly reaching 25 miles an hour. It takes about $8\frac{1}{2}$ hours to reach Ribeirao Preto, a distance of 199 miles, including twenty-two stops. Franca, at the 264th mile, is reached in three hours more, including eleven stations. There is no suburban traffic, and there are 120 trains a day on the entire system

for all purposes. Passenger trains form 34 per cent. of the mileage and 29 per cent. of the number of trains, while goods trains cover 41 per cent. of the mileage and 34 per cent. of the number, the balance being made up of mixed, service and ballast trains, the latter being large in number but small in mileage. The traffic



BRIDGE OVER THE RIO DAS VELHAS, MOGYANA RAILWAY



ROGERS SHIFTING ENGINE ON THE MOGYANA RAILWAY

of 718,761 tons represented nearly 71 million ton-miles, the average mileage being about 100 miles per ton. The average earnings are about 25 shillings 11 pence per ton, or about 3.23 pence per mile.

Several foreign railways contribute to this traffic, because, as with the Central Railway of Brazil, several small, independent branches dot the system. These lines are dependent on the Mogyana Company, with whom they have working agreements,

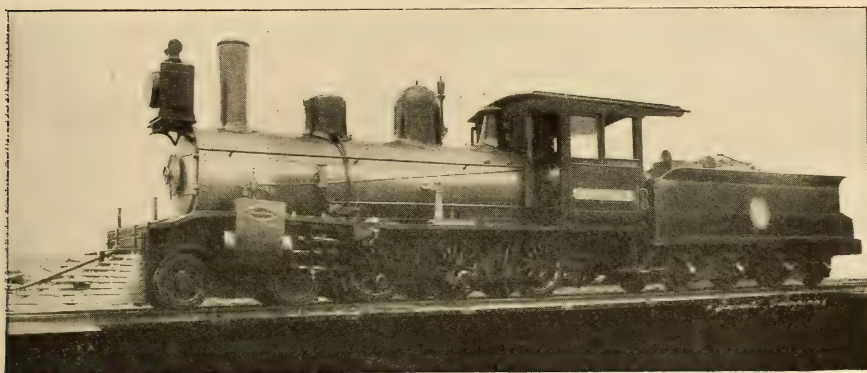
and although they are not yet incorporated with the system, they should be considered as feeder lines, whose prospects and operation are entirely similar to those of the Mogyana Railway.

Two of these lines start from Campinas, one from Bento Quirico, and one from Ribeirao Preto.

1. The Campaneiro Railway is 27 miles long, and runs from Campinas to Cabras. This line is laid to the 23½-inch gauge, and has a gradient



BALDWIN LOCOMOTIVE ON THE MOGYANA RAILWAY



LOCOMOTIVE BUILT ENTIRELY AT THE CAMPINAS SHOPS, MOGYANA RAILWAY

of 1:33, and curves above 210 feet radius.

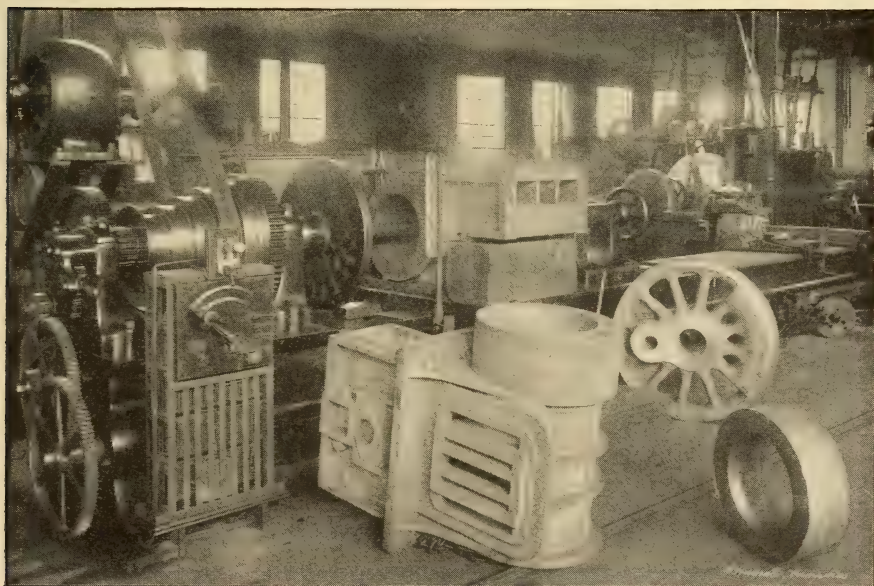
2. The Funilense Railway runs from A. Nogueira to Carlos Botelho, a distance of 26 miles. Its gradients are lighter, the limit being 1:40, but the curves are sharper, being 200 feet radius.

3. The Serra Azul Railway is laid to the metre gauge, and extends eastward from Sao Simao, and is continued into the State of Minas by the two companies which were recently amalgamated into an English one.

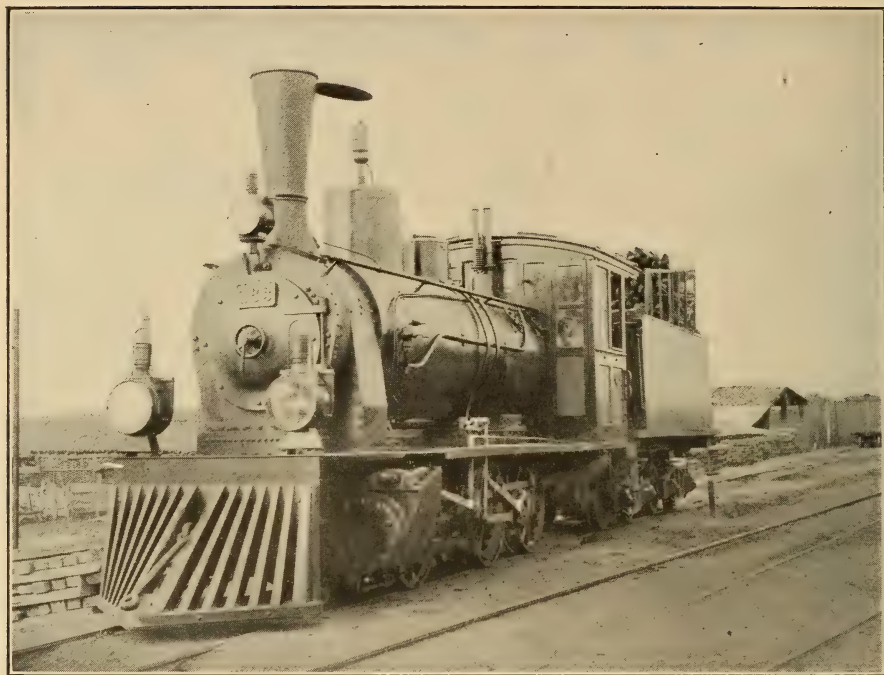
The line starts from Bento Quirico, on the Mogyana Railway, and passes through Serra Azul, Serrinha, and Matto Grosso de Batataes, its present terminal, but it will shortly reach Sao Sebastiao de Paraíso. The total length is 73 miles, and the trains connect with the Mogyana system.

4. Finally, there is the Ribeirao Preto and Guatapara Railway, which was just floated in 1910, and upon which construction work is about to be begun.

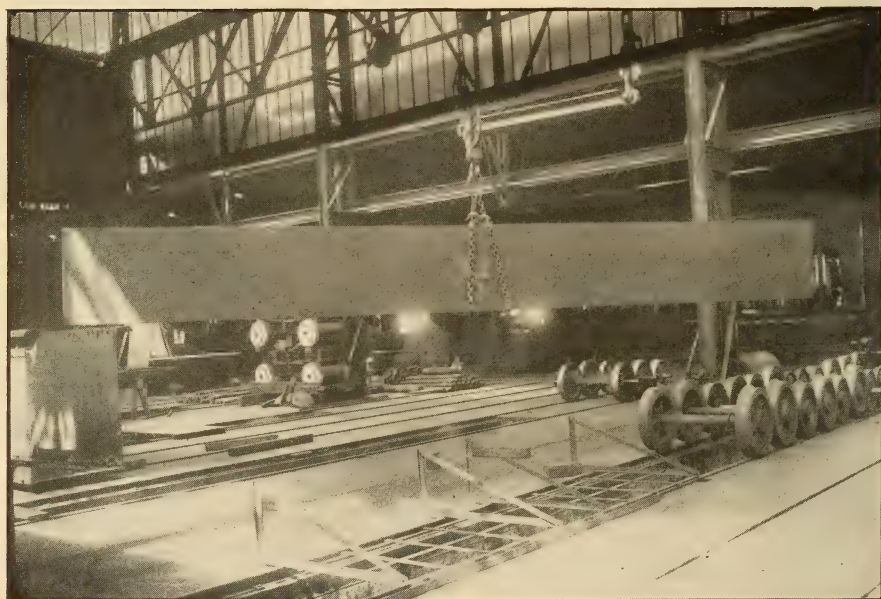
The rolling stock of the Mogyana



MACHINE TOOLS IN THE CAMPINAS SHOPS OF THE MOGYANA RAILWAY



AN ENGINE BUILT BY THE EGGERSDORF WORKS FOR THE MOGYANA RAILWAY



ERECTING FLOOR IN THE SHOPS OF THE MOGYANA RAILWAY, CAMPINAS



RAILWAY BRIDGE OVER THE RIO PARDO, MOGYANA RAILWAY

system is well up to date. It includes 122 locomotives, 161 carriages, and 1,910 wagons. The extensive works at Campinas and Ribeirao are able to take ample care of all renewal and repair work for the line. No fewer than 120 of the 161 carriages have been built at these shops, besides 572 wagons, one dynamometer car, and the only locomotives which have been constructed in South America.

A portion of the rolling stock was built in Brazil by the Rio Metalurgical Construction Company and by the Rio Edificadora Company, and the remainder by the Jackson & Sharpe Company, of Wilmington, Del.

Among the manufacturers who have supplied cars to the Mogyana Company are included the following British firms: The Bristol Carriage Works, The Lancaster Works, and The Leeds Forge Company, as well as the Jackson & Sharpe Company, of America.

Of the locomotives, about thirty have been built by the Baldwin Locomotive Works, and a few of the 2-8-2 type at the company's shops, but the majority were made in England.

Up to the close of 1908 Messrs. Beyer, Peacock & Company shipped no fewer than 40 locomotives to the Mogyana Railway, and Messrs. Sharp, Stewart & Company have supplied 45 locomotives.

THE SYSTEM OF THE BRAZIL RAILWAY COMPANY

THE Brazil Railway Company has been established, by the aid of American and Franco-Belgian capital, for the purpose of establishing easy and rapid communication between the States of Sao Paulo, Parana, Rio Grande, Santa Catarina and the neighbouring Republics. With this end in view, the Brazil Railway Company has leased the Sorocabana Railway from the State of Sao Paulo, and also the entire system of the States of Parana and Santa Catarina (with the exception of a single private line), these comprising the Sao Paulo and the Rio Grande lines in both States, and the Parana and the Dona Teresa Railways in the State of Santa Catarina, besides a large system which it has undertaken to build. The Brazil Railway also holds large interests in several neighbouring railways, practically controlling the Rio Grande system, and probably one or two of the larger railways of the State of Sao Paulo. It also holds a very close relationship in many of the more important harbour and tramway companies in Brazil, including the ports of Para and Rio Grande, the Rio Janeiro and Sao Paulo Light & Power Companies, etc. The Brazil Railway also holds a controlling interest in the Madeira & Mamore Railway Company, which has already been described in these articles.*

There is no doubt that this combination forms one of the most important railway undertakings in Brazil, being the first trust in railway enterprise which has taken place in the country.

The total development of the lines leased, operated and controlled by the

Brazil Railway Company in Southern Brazil is as follows:

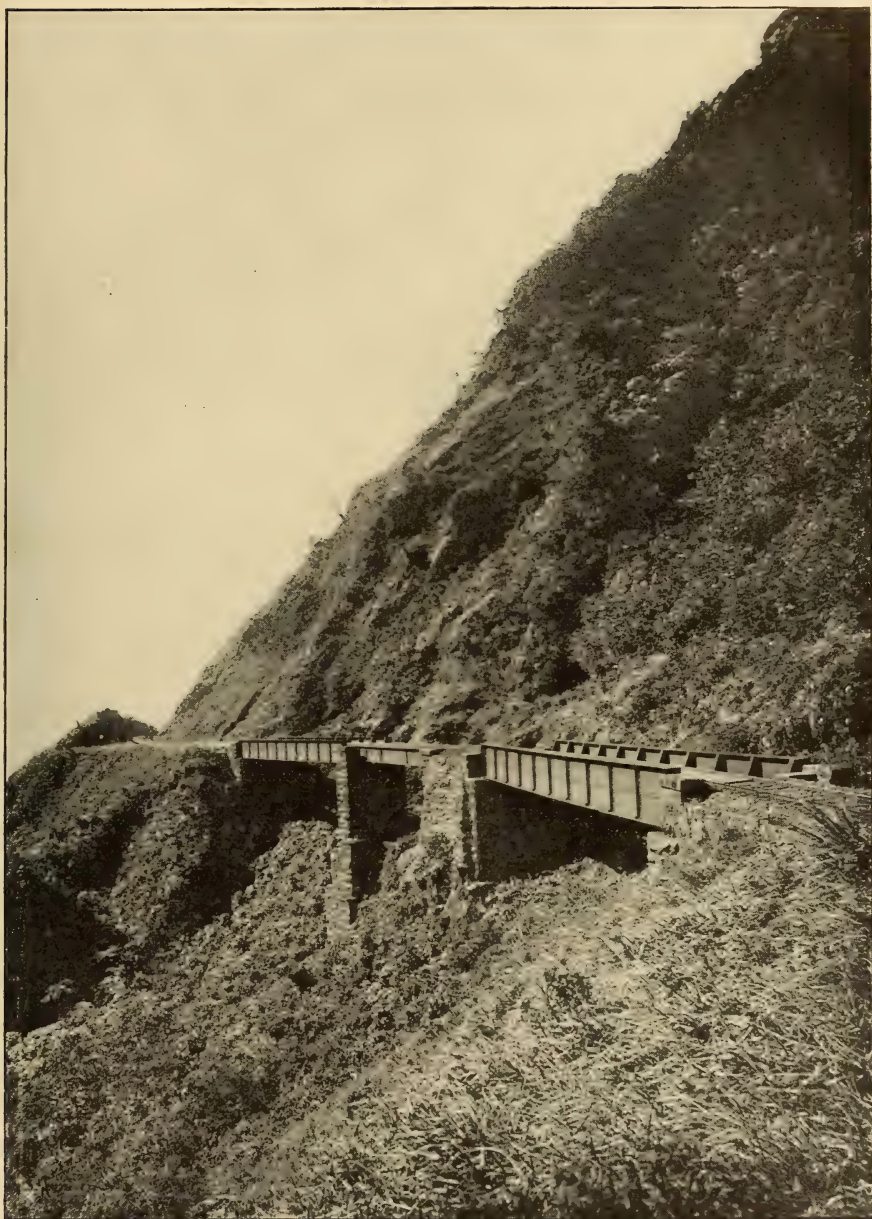
	Open to Traffic. Miles.	Under Construction. Miles.
Sorocabana Railway.....	874	101
Sao Paulo and Rio Grande.....	371	1,375
Parana Railway.....	260	
Dona Teresa Christina Railway	73	
Controlled.		
Rio Grande do Sul Railways. . .	1,256	121
	2,834	1,597

The grand total, including the Madeira & Mamore Railway, is 4,649 miles. In addition to holding the leases, the Brazil Railway Company controls the companies as the principal shareholder. It holds practically all the shares of the Sorocabana Railway (excepting only £175,000 of debentures) and 85 per cent. of the shares of the Rio Grande and the Sao Paulo lines.

The country covered by the system is a rich one. The four southern States include 316,786 square miles, and the population, which in 1890 barely reached 2,800,000, is now about 5,000,000, and increasing rapidly, since more than half the immigrants into Brazil settle in this district. The principal products are coffee, wheat, maize, rice and cotton. It is a well-known fact that coffee plantations give out after having been under cultivation for twenty-five or thirty years, and, with this knowledge in view, the Sao Paulo and Rio Grande sections of the Brazil Railway are arranging to open up a large tract of coffee-growing land to succeed such portions as may need it.

It is the present intention of the Brazil Railway Company to maintain the autonomy of the sections of which it is composed. We shall, therefore, go over them in succession, beginning with the Sorocabana, following with the Parana Railway,

* See CASSIER'S MAGAZINE, June, 1910.



A VIADUCT ON THE PARANA BRANCH OF THE BRAZIL RAILWAY

both of these being almost entirely open to traffic at the present time, and then follow with the Sao Paulo and Rio Grande lines, of which the greater portion is yet under construction.

THE SOROCABANA RAILWAY

As it now exists, the Sorocabana Railway consists of an amalgamation of two former lines: the Ytuana Company, operating a railway to the town of Ytu, and the Sorocabana



A STATION ON THE BRAZIL RAILWAY

line, running to Sorocaba. The road which was formed by the union of these two lines continued in operation until 1909, when the system was absorbed by the Brazil Railway Company.

The early history of this system is that of a struggle which continued for many years by the Ytuana and the Sorocabana Railway Companies to reach the rich districts of Botucatu and Agudos.

The Ytuana Railway was started in 1870, from Jundiahy, the terminal of the Sao Paulo Railway, and kept to the right of the Tieté river and to the west of the Paulista system, which continued the Sao Paulo Railway further into the State. A branch reached Ytu, just across the river. In the following year the Sorocabana Railway was started from Sao Paulo, keeping to the left bank of the Tieté river, and passed through Sorocaba. Any extension of one line was followed immediately by that of the other, and both railways even built portions without any guarantee of in-

terest, in order to avoid the loss of time which might be incurred.

The Ytuana line reached Piracicaba in 1879, at which time the Sorocabana Railway was still at Ypanema, but had a lease on ahead as far as the town of Tieté. Then, in 1886, the Ytuana scored a point by purchasing the short line then under construction to Porto Alfredo, together with the steamer service on the Piracicaba and Tieté rivers, and the accompanying 19-mile privilege zone. The next move of the Ytuana Railway was to survey and build very rapidly a short line on the *left* bank of the Tieté river ahead of the Sorocabana Railway from Porto Martins, on the Tieté, to Sao Manoel. This was in 1888; but the zone of operations was too narrow, and money had been spent too lavishly, and hence, having something tangible to go upon, the Ytuana Company opened up negotiations with its rival, which resulted in an amalgamation in 1892.

The original 90-year lease of the Ytuana Railway carried with it a



PRESIDENTE CARVALHO VIADUCT. PARANA BRANCH OF THE BRAZIL RAILWAY

guarantee of 7 per cent. interest on £240,000, which allowed it to reach Ytu. In 1872, a year before the first section had been opened to traffic, an extension had been asked for, obtained, and surveyed. No guarantee was granted with this, but instead the line was given permission to increase

rates should it be necessary to do so. Owing to difficulties, it was not until 1879 that Piracaciba was reached. A further extension to Sao Pedro was conceded in 1883, but as this was not in direct competition with any other line it was neglected until after 1892. This branch had a 50-year



THE SAO JOAO BRIDGE ON THE PARANA SECTION OF THE BRAZIL RAILWAY; MAIN SPAN 70 METRES LONG

lease and a zone of 12 miles guaranteed on either side.

In 1892 this company owned 138 miles of railway and 136 miles of steamer lines. In contrast to the Mogyana and the Paulista lines, its financial situation had never been a good one. The ratio of expenses to gross earnings was higher than 62 per cent. and the receipts below 5 per cent. of capital expenditure. Nevertheless, the lines had cost but little to build, being £4,857 per mile on the right bank of the Tieté river and £2,590 for the Sao Manoel extension.

Owing to some error, it was said, the entire system was laid to a gauge of 0.96 metre, or 3 feet 2 inches; but, in compliance with the bill sanctioning the amalgamation, it was converted to metre gauge in 1892. The grades reach 1 in 40, with curves of 400 feet radius, except on the Sao Manoel extension, in which grades of 1 in 38 are found and curves as

sharp as 200 feet. There are no bridges worth mentioning, the longest being only 200 feet in length.

On the two lines thus united the Sorocabana section is by far the more important. The Province had first intended joining Sorocaba with Ytu, but this plan was never carried out. A bill was passed in 1871 granting 7 per cent. interest on \$396,825 to any company which would build a line from Sao Paulo to Sao Roque, Sorocabana and Ypanema. In the same year the Sorocabana Company was floated and was granted the line by the government of the Empire, including the 19-mile zone privilege.

In 1872 it applied to the government for an increase in guaranteed capital, and by 1876 the work had been pushed to Villela, 80 miles from Sao Paulo. After this the construction proceeded very slowly, no less than three years being required to reach Ypanema. In 1881 the line to Tieté was conceded, and in 1882 the

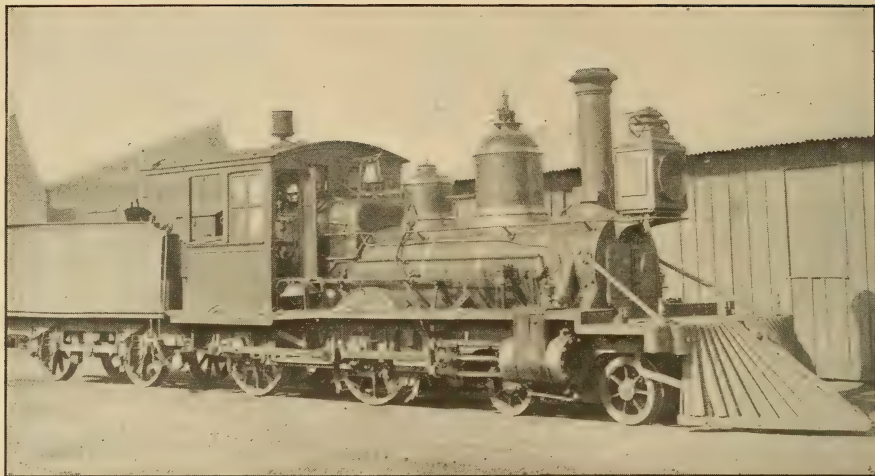


VIEW FROM TUNNEL AT KILOMETRE 64, PARANA RAILWAY

concession was extended to Botucatu. Realizing that its extensions north-eastward would always be in competition with the Ytuana Railway, the company made a definite bid for the western traffic of the State and obtained a line to Piraju, on the frontier of the State of Parana. Piraju then

bore the name of Tijuco Preto. This new orientation of the position of the Sorocabana Railway has been adhered to, and to it the present status of the system is due.

Work upon the line to Botucatu was stopped beyond Laranjal, owing to the question of the zone privilege



ENGINE BUILT AT THE FIVES-LILLE WORKS, FRANCE, FOR THE BRAZIL RAILWAY COMPANY

in opposition to the Sao Manoel extension of the Ytuana line. The quarrel was eventually carried before the government, which resulted in fixing the zones of the respective railways. The Sorocabana Railway was obliged to go around the Sao Manoel terminus of the Ytuana line, and it was not until 1889, after nineteen years of work and contest, that Botucatu, 194 miles from Sao Paulo, was reached.

Within three years from its opening the receipts of the railway had more than trebled, as had also the grievances between the two lines. The same year, 1889, saw the opening of a small branch to Tatuhy. This small branch has become, twenty years later, the first section of one of the most important railroads in South America, as it is included in the Buenos Ayres, or Montevideo through route to Rio de Janeiro.

This Tatuhy branch had been leased in 1888, together with the second extension of the railway towards the State of Parana, through Tatuhy to Faxina and Sao Pedro de Itararé, on the frontier.

Then, in 1892, the amalgamation of the Sorocabana and Ytuana Railways was effected, after a conflict of twenty-two years.

The Sorocabana and Ytuana union

naturally began its work by building two connecting lines:

1. A road from Victoria to 13 de Mayo, connecting Botucatu with the Porto Martins branch, and opened in 1893;

2. A line from Ytu to Mayrink, connecting the trunk lines of the two former companies, this being opened in 1898 and to be extended to Santos.

The main line to Botucatu, along the Tieté river, has been extended to Bauru, beyond Agudos, where it meets the Paulista Railway. We have already seen how the latter intends to compete for the traffic of this district. The distance from Bauru to Sao Paulo is 274 miles over the Sorocabana Railway and 271 miles over the Paulista route. The Tatuhy branch has been lengthened into a line running through Itararé into the State of Parana, this being open to traffic all the way. The distance from Itararé to Boituva Junction is 205 miles.

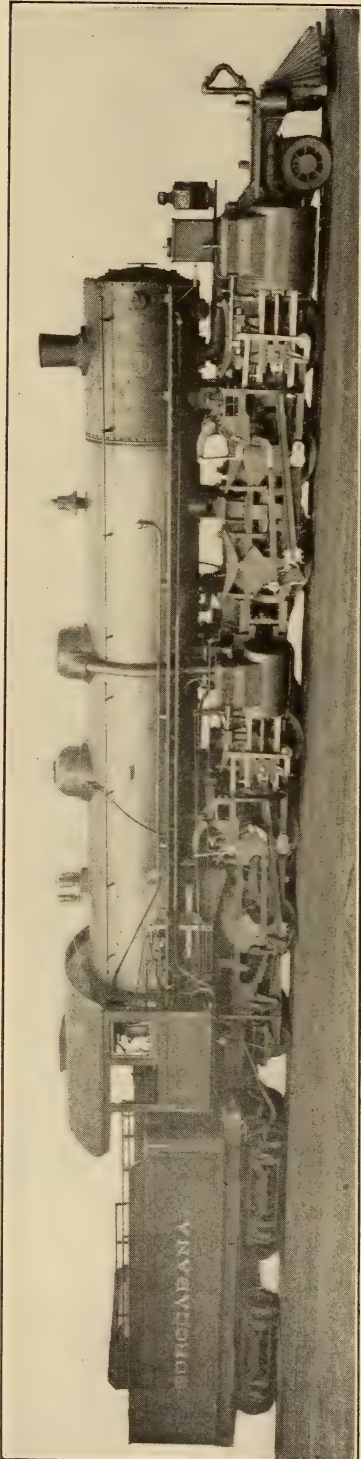
Finally, a new line has been started, due west from Botucatu, into an entirely new district, and one which is certain to develop a considerable amount of traffic in the near future. This line reaches the Paranapanema river at Salto Grande, at the beginning of navigation, a point which was originally intended to be the terminal



UP THE SERRA ON THE PARANA BRANCH OF THE BRAZIL RAILWAY

of the railway. Powers have since been granted, however, to extend the line to Agua Boa, and, in 1910, to Tibyrica, at the mouth of the river, on the banks of the Parana. The line is open to traffic as far as Ilha Grande, a town situated near the Paranapanema river, and about as

for from the Rio Pardo, an important tributary further north. Two branches have been opened from here, one extending southward to Piraju, on the Paranapanema, and the other northward, from B. do Campos to Santa Cruz, on the banks of the Rio Pardo; this latter branch is to



MALLET COMPOUND ENGINE FOR THE SOROCABANA RAILWAY. BALDWIN LOCOMOTIVE WORKS

be continued beyond the river to Campos Novos. Construction work on the main line is proceeding from Ilha Grande on to Salto Grande.

The portion of the line leaving Sao Paulo was difficult of construction, since it immediately encountered the Itaqui range of mountains, which had to be crossed before the Sorocabana valley was reached. The grades reached 1 in 43, with curves of 264 feet radius. Three tunnels were required, of 594, 660 and 66 feet in length, respectively. Beyond Sorocabana the work became less difficult, the smallest radius of curvature being 400 feet, and the maximum grade 1 in 50. The cost of the lines was approximately £8,095 per mile.

Prior to 1890 the company had a hard time, but by that time dividends reached 5 per cent., and from 1894 to 1899 they went up to 8 and 12 per cent. But little returns came from the old Ytuana system, most of its former traffic being diverted to the Sorocabana lines. The ratio between working expenses and gross earnings, which was 70 per cent. at the time of the amalgamation, was brought down to 52.2 in 1898. Complaints existed as to the operation, however, and in 1905 the State of Sao Paulo bought the system back for £4,535,714. As there was then 616 miles open to traffic, this corresponds to a cost of £7,363 per mile. The *Uniao Sorocabano e Ytuana* was dissolved, and a new Sorocabana Railway leased the system for a period of sixty years from May 22, 1907. This is the company whose shares are now the property of the Brazil Railway Company.

The new Sorocabana Railway Company has undertaken to pay all expenses due to the loan of the Dresdner Bank to the State of Sao Paulo, besides 6 per cent. of all expenditure, due either to the construction of new lines or the improvement of old ones undertaken by the State of Sao Paulo. The company then takes a sum equal to 6 per cent. of all its own expenses, whether capital

THE RAILWAYS OF BRAZIL

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expenditure, construction or improvement work; a quarter of the remainder is then given to the State.

A curious practice of the Sorocabana Railway, as of many other railways in Brazil, is the use of variable rates, the charges varying monthly, according to the exchange.

The most recent branch conceded to the Brazilian Railway is one from Santos to Burra de Sao Antonio de Jecquie, in 1909. This seems to indicate the probability that the Brazil Railway Company is to build the Santos extension. There is no doubt that it is of the utmost importance that the Brazil Railway should run its trains direct to Santos; but it would be simpler and also better policy to lay a line alongside of that of the Santos & Sao Paulo Railway, or to provide the existing track with a third rail to the metre gauge. The old inclined planes, now used only in cases of emergency, could be devoted to the metre gauge trains, while the broad gauge ones used the new inclines. Whichever plan be adopted,

EX YTUANA COMPANY.		Miles Open
Jundiaby to Ytu.....	Main line***	44
Itaicy to Sao Pedro.....	Main line***	94
Joao Alfredo Chave.....	Branch***	11
Porto Martins Araqua.....	Branch***	23
SINCE THE UNION.		
Victoria to 13 do Mayo.....	Connection***	10
Ytu to Mayrink.....	Connection***	34
Mandury to Ilha Grande, extension.....	Main line*	66
Ilha Grande to Salto Grande...	Main line*	Building.
Salto Grande to Tibyrica.....	Main line*	Surveying.
Mandury Piraju.....	Branch***	16
B. do Campos to Santa Cruz...	Branch***	15
Santa Cruz to Campos Novos, extension.....	Branch***	Surveyed.
Mayrink to Santos.....	Main line**	Conceded.
Santos to Sao Antonio.....	Branch***	Conceded.

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* Conceded by the government of the "Union" with guarantee of interest.
 ** Conceded by the government of the "Union" without guarantee of interest.
 *** Conceded by the State of Sao Paulo.

It may be of interest to compare the data referring to the Sorocabana Railway with those of the other important Brazilian railway companies included in the central railway group; this includes the Paulista and Mogyana Railways, its neighbours and competitors in the State of Sao Paulo, as well as the Central of Brazil, from Sao Paulo eastward.

The figures given are all for the year 1908. The Central of Brazil

	In 1908.	Sorocabana Railway.	Paulista Railway.	Mogyana Railway.	Central Railway.
Mileage.....		715	661	853	1,102
Staff.....		3,029	3,861	3,875	12,470
Locomotives.....		83	134	122	302
Vehicles.....		1,296	2,681	2,071	3,375
Gross receipts.....		£769,997	£1,416,527	£1,152,916	£1,904,910
Working expenses.....		£433,131	£651,061	£622,862	£2,011,398
Working percentage.....		56%	46%	54%	105%
Re ton of goods hauled one mile:					
Receipts.....	Pence	3.66	3.86	3.72	1.84
Expenses.....	Pence	2.06	1.77	2.00	1.94
Ton miles per official.....		16,780	22,939	19,326	20,035
Locomotive miles.....		2,100,196	2,481,446	2,897,586	6,205,888
Vehicle miles.....		10,764,863	36,065,558	21,214,921	59,541,168
Average number of miles run per vehicle.....		8,306	13,452	10,244	27,716
Average number of ton miles per vehicle.....		39.22	33.03	36.16	74.03

there is no doubt that trains of the Brazil railway will shortly reach Santos.

Thus the Sorocabana Railway is at last in a prosperous condition; its gross earnings in 1908 were £769,997.

The following table gives the mileage of the present system:

Line.	Miles Open.
EX SOROCABANA COMPANY.	
Sao Paulo, Vilella, Botucatu... Main line***	194
Botucatu to Bauru..... Main line***	80
Boituva to Itarare..... Main line*	204
Capao Bonito to Mandury..... Main line*	78
Cerquillo and Tiete..... Branch line***	5

Railway is owned and worked by the government, which is immediately apparent from the number of railway officials.

The Sorocabana Railway still runs steamer services on the Rios Tieté and Piraciba, altogether a distance of 99 miles. The former service is maintained between the towns of Porto Martins, to which one of its branches leads, Eliza, and Ribeirao. The Piracicaba service is maintained between Villa Maria, Porto Rozario and Joao Alfreda, the terminus of the branch of the old Ytuana line.

The company owns four steamers (the *Visconde de Ytu*, the *Piraciba*, the *Souza Queiros*, and the *Bauru*), seven launches, and a lighter.

The system is now well worked, as the previous table shows, and compares favourably with those of the neighbouring railways.

The standard coffee trains are made up of twenty freight cars of 24 tons capacity each, which are hauled on the easier portions of the road by 50-ton consolidation locomotives. There is, however, a portion of about 30 miles in which the ruling grade is about 1 in 50, and, to avoid the use of banking engines or of dividing the load on this section, the Sorocabana Railway has recently put into service some powerful Mallet locomotives.

These engines, built by the Baldwin Locomotive Works, and arranged for wood burning, are remarkably heavy and powerful, considering that they are of the metre gauge, the total weight being 190,800 pounds, of which 161,200 pounds are adhesive. The tender weighs 89,200 pounds, bringing the entire weight up to 280,000 pounds. The tractive power of such an engine, calculated by the American formula, with a

coefficient of 85, is 37,600 pounds.

The other locomotives of the company are eighty-two in number, the typical passenger engine being of the 4—4—0 type and the freight engine of the 2—8—0 type; but recently some new passenger locomotives of the 4—6—0 type have been added. A few of these locomotives are British (Fairlie; Sharp, Stewart & Co.; Hawthorn, Leslie; Dubs, etc.), but the majority are American, and were built by the Baldwin Locomotive Works.

The coaches include 30 first class, 33 second class, and 10 composites, besides 4 sleepers and 20 vans, bringing the total up to 97. In addition, there are 1,245 freight cars. As is the case with most of the Brazilian railways, the greater portion of these were built in Brazil or in Belgium.

The sleeping cars were built in 1908, by the American Car & Foundry Company and by the Jackson & Sharp Company. These sleeping cars now run from Sao Paulo to Ponta Grossa and Curityba, performing the journey in twenty-seven hours. The charge for lower berths is 10, 20 or 30 milreis, according to distance, the charge for upper berths being one-half these prices.

CARBURETTERS AND VAPORISERS

By T. A. Borthwick

The development of the internal combustion motor for use in the automobile and aeroplane is closely connected with the apparatus for converting liquid combustibles into the gaseous state. The motor is operated, not with liquid, but with gaseous fuel, and before the combustible is introduced into the cylinder it must be converted into such a gaseous state that it may be mixed with the proper proportion of air to form the explosive charge. Mr. Borthwick here discusses the various forms of carburetters and vaporizers for use in this important stage of the work, showing the lines along which further development may be expected.—THE EDITOR.

AN analysis at all approaching completeness of even one-tenth of the carburetters for vaporising petrol or paraffin that are now being manufactured, either as belonging to a definite machine or being placed on the market as an accessory, would be a work extending to several volumes. The scope of this field may be gauged by a glance at the patents review of the technical journals, where two or three specifications of newly patented designs may be found almost every week. It is, therefore, not intended here to deal with them fully as regards their mechanical arrangement, but to consider the conditions most favourable for the economical and satisfactory production of a combustible fuel, and to trace its path from the entry into the float chamber until it reaches the combustion chamber.

It may be taken primarily that the use of a jet, of which the effective level is regulated by a float chamber, as originated by Maybach, is almost universally adopted in all cases in which petrol is the fuel. This type is also used to a very large extent in engines using refined and semi-refined paraffin. It is with devices of this kind that this article will deal.

It is a matter for surprise that the use of such a delicate and uncertain piece of apparatus has not been avoided. In fact, the float chamber has received very little attention beyond the arrangement of the balance weights, or in attempts to dispense with them altogether.

The arrangements shown in Figs. 1, 2 and 3 are those most commonly adopted in current practice. Fig. 1 is arranged so as to admit the lightest possible working parts and thus minimize the troubles due to inertia when traveling over uneven roads; it has the further merit that any surplus of petrol escaping on account of vibrations of the needle valve causes the float to press more heavily on the balance weight, and thus to close the valve more tightly on its seat.

The arrangement shown in Fig. 2 requires the needle and its fittings to be somewhat heavier than in Fig. 1, since the pressure due to the weight alone acts to keep the valve on its seat. The design shown in Fig. 3 has the merit of simplicity, and has also the same advantages as Fig. 1; but it is open to the objection that the petrol pipe has to be uncoupled every time the float chamber is opened, an occurrence which happens not infrequently, especially with paraffin.

Among improvements relating to the float chamber that known as the Gillet-Schwarz device is one of the more important. This consists of a through connection between the mixture pipe and the space above the fuel pipe in the float chamber by means of a branch pipe to which is attached a cock, making the effective area of the through connection adjustable. The resultant effect of this device is to tend to produce a constant ratio between the pressure in the float chamber and that over the

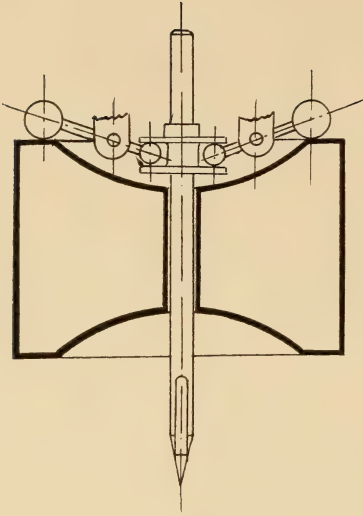


FIG. 1.—DIRECT NEEDLE VALVE

jet, or, in other words, to produce a constant effective height for the jet, and, therefore, on the wider opening of the throttle, to give a weaker mixture. It may, perhaps, be desirable to explain the desirability of this weakening of the mixture with the opening of the throttle by reminding the reader that, with a partially closed throttle, the cylinder is only partially filled; consequently,

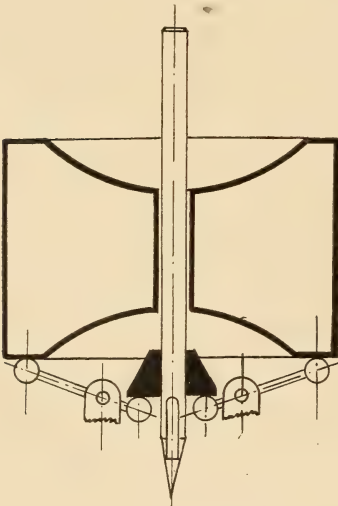


FIG. 2.—INVERTED NEEDLE VALVE

the compression pressure is lowered, and a richer mixture is required to enable it to be ignited. The best pressure ratio is obtained experimentally by opening or closing the cock in the by-pass, as may be required. Another, and perhaps more valuable, quality in the Gillet-Schwarz device is, that in multi-cylinder engines it discriminates between the supplies of mixture to each cylinder; e. g., in four, and more particularly in six-cylinder engines, it will frequently be found that the mixtures are required of different strengths for the different cylinders, as

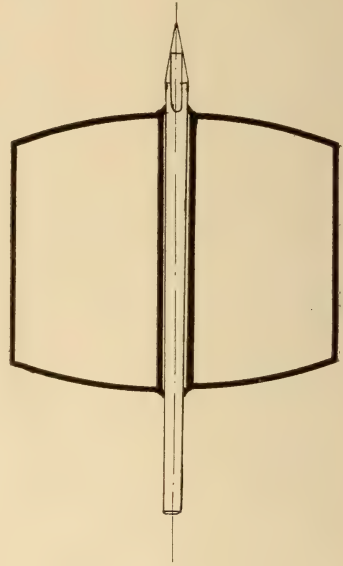


FIG. 3.—FLOAT AND NEEDLE VALVE

shown by the fact that some of the cylinders will fire weakly or miss altogether, while the remainder will fire well. This is partially due to variations in the volumes of the combustion chambers, but more largely because of leakage past valves and valve covers, and perhaps it is also due to a still larger extent to the timing of the valves not being uniform throughout the cylinders. This device assists in partially neutralizing the last two faults, since the effective height of the jet being ap-

proximately constant, the cylinder with the stronger suction will draw the moist air, and as it will have nearly a uniformly higher compression, the ignition of the charge is assured. On the other hand, the cylinder with the weaker suction, and consequently weaker compression, will draw less air, thus forming a richer and more readily fired mixture.

After mentioning the above device, we may add that the same principle has been utilized in a carburetter brought out by Messrs. Cravens, Ltd., of Sheffield.

Little else need be said with regard to the float chamber except, perhaps, a note about the position of the hole between the float chamber and the jet. One frequently finds that this is situated at the bottom of the chamber, where it draws any grit or sediment which may find its way inward. The hole should be at least a quarter of an inch from the bottom, or preferably more, since even if a petrol filter is provided, one finds that dirt still finds its way in by some mysterious means. It must also be remembered that it is not safe to assume that adequate precautions are taken to exclude all dirt when the petrol pipe is uncoupled or when the float chamber cover is removed.

A final item to be noted is the needle valve. It is frequently found that this is made of mild steel, and, therefore, exceedingly liable to become rusted in the presence of petrol; it should, therefore, be made of a high-percentage nickel steel, or of silver steel.

Before dealing with the details of the mixed chamber it is desirable to consider the general disposition of the mechanism of the carburetter. For purposes of comparison, we may divide all carburetters into two classes—vertical and horizontal. Referring to the former class, it may be noted that the vertical carburetter usually gives a more direct flow for the gases, has fewer bends, is more

economical in fuel consumption than the horizontal type, and is, furthermore, not so liable to become choked. As an offset to these good qualities the horizontal carburetter is undoubtedly easier to be started, since the incoming air rushes directly across the top of the jet instead of flowing along it.

We will now consider some of the very simplest forms of carburetters, being those without any kind of automatic controlling device for the auxiliary air inlet, and hence without any means of discrimination between the requirements of a full throttle at low speeds and the same at high speeds. This class of carburetters is by no means the largest; but, speaking generally, they give singularly satisfactory results, very nearly equaling those attained by carburetters provided with the most accurate adjustments. Under these circumstances one is almost inclined to wonder whether, for practical purposes, the extra complications and delicate parts of the more refined devices are warranted.

Taking a few typical examples of this class, we will first examine the White & Poppe carburetter, which is well to the fore in its line. The general arrangement is shown diagrammatically in Fig. 4, from which it will be seen that a vertical rotary throttle is placed in the path of the inlet gases and that the throttle casting forms a shroud over the jet, a petrol-tight joint being formed between it and the conical top of the jet and the shroud being kept on its seating by means of the spring *A*. The hole in the jet and the shroud is disposed eccentrically in such a way that the jet, the air inlet and the mixture outlet are all cut off simultaneously and in a definite, predetermined proportion. A simpler and more satisfactory way of effecting this three-fold function could hardly be imagined. The only adjustment of any kind is that for the air outlet, by means of the sleeve interposed between the throttle and the casing.

This is operated by moving two stops on the chamber cover, and compensates for varying atmospheric conditions, and also for different qualities of petrol.

The remaining portion of the White & Poppe carburetter is a short trunk placed between the mixture outlet and the engine inlet pipe; it serves the purpose of removing any heavy particles of petrol, therefore making the mixture more homogeneous. We believe, however, that this atomizing chamber has been omitted in the latest designs of this carburetter.

An approximately similar carburetter, but of the vertical type, is the Claudel-Holson, which, however, has a different kind of jet, and one which is both ingenious and interesting. Referring to Fig. 5, the hair-line circle represents the throttle, and it will be seen that the jet outlet, and also the holes in the sleeve surrounding the jet, are enclosed by the throttle, while the holes at the bottom of the sleeve are outside the jet. The function of the sleeve may be explained as follows: Assuming a partially closed throttle, the holes at the top of the sleeve will be in a partial vacuum, caused by the suction of the engine, while the holes at the bottom will be approximately at atmospheric press-

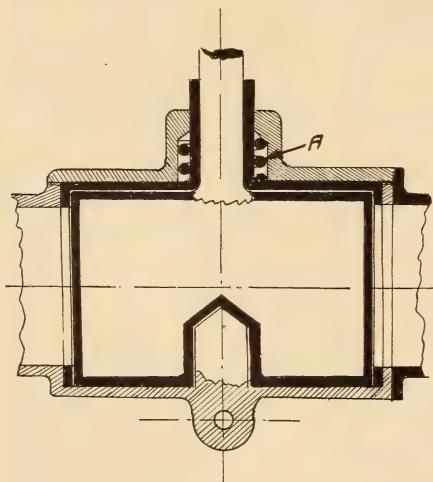


FIG. 4.—WHITE & POPPE CARBURETTER

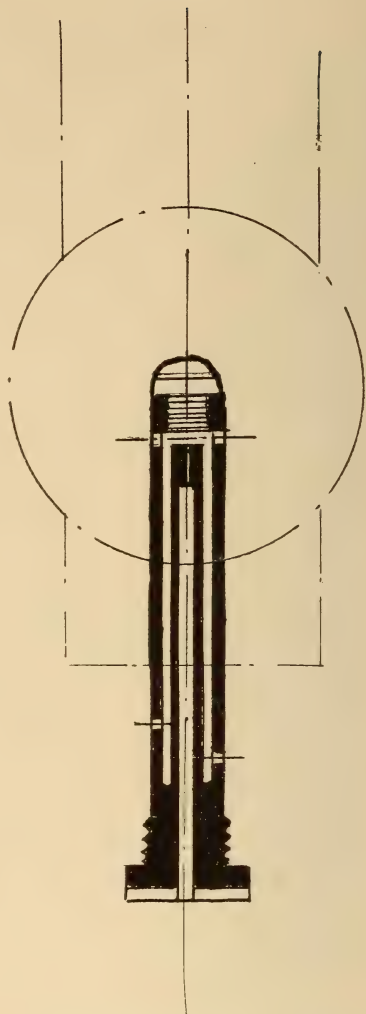


FIG. 5.—CLAUDEL-HOLSON CARBURETTER

ure. A current of air will, therefore, pass upwards inside the sleeve and draw upon the jet. If, however, the throttle were fully open, the top holes would be nearer atmospheric pressure, and the pressure difference between the top and bottom holes would be less, and, therefore, there would be less suction on the jet from this source.

By these means the requirements of proportionately richer mixtures for the tighter throttles are effectively and simply met. It may be added that the Claudel-Holson is an

exceedingly well constructed and designed carburetter, affording a specially smooth and straight forward flow for the gases.

Another example of this type of carburetter is one which has been fitted on the Belsize cars. It is of the vertical type, and is so arranged that a throat of constant size is maintained, but that, simultaneously with the rotation of the throttle, a screw of quick pitch is also rotated, and by its means a sleeve is lifted in a circular chamber, coned inwards, and therefore the effective air-inlet is increased, and the mixture is atomized higher up in the carburetter, prior to reaching the throttle. Further examples of this type of carburetter are the Trier & Martin triple jet, the Craven, already mentioned under the heading of float chamber, and the H. P. carburetter. This latter has a simple means by which, if desired, air only may be drawn into the engine, after the complete closing of the throttle.

As regards the jet, it may be mentioned that it should be kept as large as possible, in order to lessen the disturbing and fluctuating influence of friction. Since, however, for slow running, with no load, the quantity required is almost infinitesimal, the idea of providing a separate jet or a variable jet to serve this purpose may be worthy of consideration. The former method, of a separate jet, is probably the better one of the two, unless some method is adopted similar to that used in the White & Poppe carburetter, in which the jet is cut off eccentrically. The earlier method adopted by a number of makers, of lowering a taper needle into the jet, is not nearly so good, since capillary attraction and jet friction combine to make the supply very variable. It should be emphasized, however, that the secondary jet is to be used solely for the purpose stated, and should be neutralized, or, preferably, cut off positively for working positions under load.

It may be recalled that a year or

two ago several triple and quadruple jet carburetters were brought out, but these have, for the most part, since been abandoned. These would obviously have an abnormal amount of jet friction and, therefore, be sluggish in action. For reasons already stated, they would not give uniform results, as the friction, even under uniform atmospheric conditions, does not remain a constant quantity.

A form of jet, as fitted to the Itala and other vertical carburetters, may here be mentioned; it is shown in Fig. 6. It will be seen that the petrol is compelled to leave the jet head radially; the object is to integrate it with the incoming air, but it is somewhat questionable whether it penetrates any further into the stream of air than that which immediately surrounds the jet.

In considering the subject of the throat of a carburetter, several features should be taken into account.

So far as the surfaces are concerned, one has only to compare the action of a rough and a machined throat of similar dimensions to appreciate the influence of the nature of surface upon performance. We may also add that we have found engines to run appreciably better with inlet pipes made of solid-drawn copper tubing than when made of castings of similar shape and size.

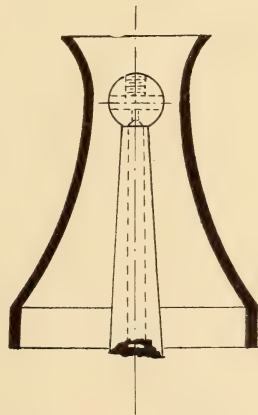


FIG. 6.—ITALA CARBURETTER

When a carburetter for petrol is fitted with a throat of constant diameter, it will be found that the most satisfactory size is that which gives the air a velocity of about 100 feet per second for a horizontal throat, or 120 feet per second for a vertical throat.

Taking, as an example, an engine of four inches bore and five inches stroke, and capable of being throttled down to 160 revolutions per minute, the carburetter, assuming the cylinders to be properly filled, should have a throat area of 0.358 square inch, corresponding to about 11/16 inch diameter, when of the horizontal pattern, and 0.298 square inch, or 5/8 inch diameter, if of the vertical pattern.

It is, however, more than probable that when the engine is idly rotating at that speed, the throttle aperture does not allow the cylinders to become more than one-third full. To cover this condition, and also to get the best mean for general working, it is advisable to fit a cut-off for the throat, although this is not generally provided. On the White & Poppe carburetter, the throat is mechanically enlarged, and it is found that an engine of the size given above will run very light, when in good condition, at 160 revolutions per minute, with an effective throat-area equivalent to a diameter of 3/16 of an inch.

This throat reduction is done in a very ingenious manner in the Trier & Martin carburetter. In the earlier patterns a vertical shutter was hung across the throat, and cut off all but a small portion until the suction of the engine became powerful enough to lift it out of the way. More recently the same makers have used a device shown in Fig. 7, which is self-explanatory; the suction of the engine pulls the spring, and allows additional air to pass between the coils. A similar spring device has been used to operate an auxiliary air inlet.

In many carburetters of the hor-

izontal pattern, there is no reason why a much greater application of the *vena contracta* should not be made, and the throat enlarged accordingly. Taking the case which we have already considered, that is, a throat 11/16 inch diameter, and also take the *vena contracta* constant

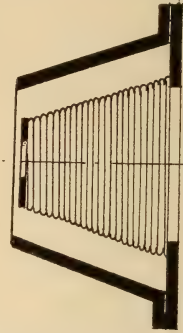


FIG. 7.—TRIER & MARTIN NOZZLE

as 0.6, we might enlarge the throat to 0.37: 0.6 square inch, or 0.601 square inch, or 7/8 inch diameter, and place the jet where the contradiction occurs. This plan could, of course, be quite logically adopted with vertical carburetters, but the application of it would present some difficulties in the arrangement of the parts.

Regarding the use of other spirits than petrol, it may be mentioned that benzol, methylated spirits, and also benzine, may all be used without alteration to the petrol carburetter, other than the change in the size of the jet. Benzine is somewhat slow and heavy in its working, but methylated spirit gives an exceedingly lively engine and also very good results from the point of view of power output; but it also makes an engine which is somewhat too "hard" in working for general use.

The use of fuels of the paraffin type, such as the American White Rose, or Royal Daylight, the Russian Russolene, Scottish Lighthouse, Burma Victoria, or refined Borneo, and the numerous other oils of approximately the same nature, also the heavier and more sluggish spirits, such as the usual commercial grades

of naphtha, presents no very great difficulties, after the few necessary modifications have been made in the design of the carburetter.

It is necessary, primarily, to provide a vaporiser which may be heated by the exhaust gases of the engine, or by other means, such as a blow lamp. This vaporiser should be so designed that as large a surface as possible is presented to the incoming mixture, in order to prevent the formation of a core of unvaporised mixture; this latter condition being apt to occur if tubes of at all large diameter are used.

The method of drawing in the air is different from that used with the

petrol carburetter. With the carburetter for paraffin, the amount of air passing through the throat must be only sufficient to lift the oil out of the jet and carry it onward, so that the unvaporised mixture is not sufficiently rich in oxygen to become ignited in the vaporiser.

The additional air required to form the explosive mixture is taken in by means of a separate valve between the vaporiser and the engine inlet valve. There are a few carburetters for paraffin on the market as a specialty, the majority being the exclusive designs adapted to and confined to the engines of the makers.

DESIGN AND APPLICATION OF THE MODERN BALL BEARING

By J. F. Springer

IF we preserved the record of the earliest efforts of men to move heavy loads, they would no doubt disclose a crude but real attempt to substitute rolling for sliding friction. The possibility of using the trunks of trees as rollers to effect the horizontal movement of a great stone could not long escape discovery. The difference between dragging the stone and moving it along on rollers is too marked not to have made a strong appeal even to an industrial imagination just awakening. But this difference between a drag and a roll is practically the thing which makes the most modern of ball and roller bearings attractive to the highly trained mechanical intelligence of the present day.

We must not imagine, however, that rolling friction is no friction and that a ball bearing constructed with perfect accuracy would have absolutely no frictional resistance. Rolling friction may be only a small fraction of the corresponding sliding friction, but it is real just the same. There are two distant frictional elements in rolling. Because materials which we term solid are not absolutely so, but possess structure, it is mechanically impossible to produce surfaces absolutely smooth. So that when a highly polished steel ball rolls upon a steel surface equally polished we are bound to conceive that mutual penetration occurs at the point of contact. The introduction and withdrawal of material particles occurring in the interpenetration must give rise to minute local deformation and abrasion. The consumption of energy occasioned by overcoming the resistance thus set up constitutes one ele-

ment in rolling friction. Just as the most highly polished surfaces really possess a minute roughness, so metals and other solid materials are not absolutely incompressible under load. There is a yielding of the metal, both in the ball and raceway, resulting in an evanescent deformation. There is a flattening of the ball in the region of contact. Just how far the locus of deformation extends no one, probably, knows. But the deformation is real and must be taken into account. The raceway is likewise locally deformed. The production of these deformations consume energy. We have here the second element in rolling friction. In steel bearings, it is probably much the greater of the two.

In sliding friction, as with a journal in its box, there is the work concerned in interpenetration and in local deformation. But the great consumption of energy centers in the abrasion, consequent upon the movement of interpenetrating surfaces perpendicular to the common normal. That modern investigations as to the behaviour of lubricants have provided a means of securing heavy reductions of this class of friction is not to be denied. It seems possible, also, that under ideal conditions a journal may really be rotating upon a film of oil entirely out of contact with its box. At present, however, the elimination of friction is, for the bulk of the cases, to be sought in the direction of the substitution of rolling bodies for sliding ones.

The development of the modern ball bearing has not been an uneventful one. Many corpses strewed the road. The records of the United

States Patent Office disclose hundreds of ball bearing inventions. Perhaps the majority of these manifest a thought or an effort in the right direction. But it takes more than one swallow to make a summer. One or two good ideas embodied in an invention may be interesting to the historian as he reviews the development. But many devices—and the ball bearing is one of them—involve in their successful application to high duty not one, but many steps in the right direction. In the old bicycle days there were many varieties of ball bearing. And there was a great deal of success. But the duty was light both as to load and to speed. And so it came to pass that when under the spur of the fine results with the bicycle, this device was applied to real machine duties, it soon became apparent that something was wrong. Even with the bicycle, balls would occasionally break. But no great harm would result. Designs which really assumed that the balls were spheres, that the races were round and that steel was incompressible were successes with the small demands of the bicycle in spite of failure to realize every one of these particulars. The same or similar designs proved very poor with the severe requirements of the automobile and other machines. The best designs of to-day also assume that the balls and raceways are round. But the necessity for their being so is now very well understood. Steel is no longer implicitly assumed as undeformable. It is now dealt with on the basis of exactly what it is—a hard, elastic and compressible material. With a frank recognition of things as they really are, and not as it would be convenient mathematically to assume that they are, great success is attending the employment of the ball bearing in situations involving the performance of excessively severe duty. In order to understand the failures of the past and the successes of the present and the ex-

pectations for the future, it will be necessary to understand some of the principal occurrences in a bearing when in operation.

When a circle rolls along a line the point of contact is forever changing not only relatively to the line, but relatively to the circumference. At any instant a point or particle of either is in contact with a point or particle of the other. Immediately before and immediately after this instant there is no such contact. Now it is fundamental to the idea of all rolling that *at the instant of contact* both particles shall be, relatively to each other, absolutely quiescent. This is a necessary condition. If we draw a diameter to the point of contact it will be for the moment a radius of rotation, and its several points will have velocities parallel to the line proportional to their distances from the centre of rotation. The farther end will therefore have precisely twice the velocity of the centre of the diameter. It is very true that the particle at the outer end is continually changing and that in consequence an individual particle possesses the described combination of velocity and direction for the instant only. But suppose we imagine a tangent line at the outer end and parallel with the other line. If its contact with the circle is also a rolling one, it will be driven forward with the velocity and direction possessed by the circumferential stream of particles at the contact moment. We thus arrive at the important result that when a circle is rolled between two lines in the same planes, whether straight or not, the centre of the circle has a velocity equal to one-half the velocity of the driving line. Thus, if a ball is rolled between two cylindrical raceways, it will have a linear velocity along the circle of centres equal to half the linear speed of the driving raceway along the circle of contact.

Let it be noticed that as one circle rolls round another, every particle in the rolling circle will trace out an

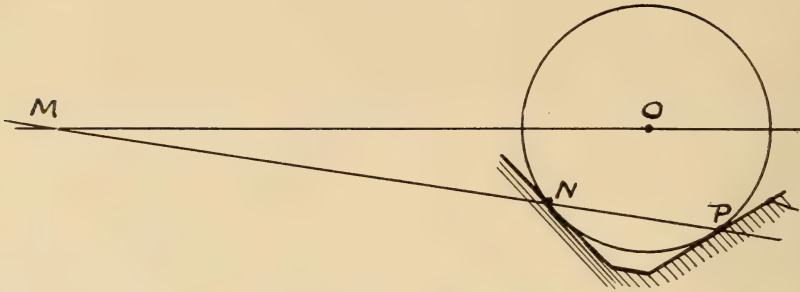


FIG. 1.—BALL AND GROOVED RACEWAY

epicycloid to some circle. But the centre, because forever at a constant distance from the centre of the fixed circle will simply trace out a circle. Relatively to its centre, all points of the rolling circle will rotate round and round. Similarly, the ball rolling on a cylinder will have an axis passing through its centre and parallel to elements of the cylinder, upon which it rotates as it rolls. This is the *axis of rotation*.

Consider now Fig. 1, where we have an axial section through a ball and grooved inner raceway. In rolling along such a groove, there are two points of contact upon which, for the instant, the ball rotates as round a pivot. But pivotal rotation is really axial rotation. And so the only way to harmonize double pivotal rotation is to assume the line through the two points as the axis of rotation. The ball in the figure is consequently, for the moment, rotating on *MP* as an axis. Because of its evanescent character, this line is called the *instantaneous axis of rotation*. It is one of the most important elements in ball bearing design.

This instantaneous axis will trace out, as the ball rolls, a right cone whose vertex lies on the axis of the shaft. A line drawn from this point through the centre of the ball will pass through a line of particles which do not partake of the rotation of the ball, but only of its revolution. The line *MO* is thus the axis of rotation. It is to be carefully distinguished from the instantaneous axis of rotation.

Now, if the ball contacts with another, an outer, raceway, there will be determined, as the two move on in rolling contact, a second instantaneous axis of rotation. In turn, this will determine a second axis of rotation. Now, manifestly as the ball revolves, it can have but one axis of rotation. This is just as true as that the earth could have but a single axis at any one moment. These principles impose a condition upon design. The faces of two grooved raceways must be so related as to determine but one axis of rotation. Otherwise the ball would be continually in the throes of a contest, which could only be composed by slippage between ball and contacting surfaces. This law as to the axis of rotation must be observed, then, in all *four-point* bearings. A necessary and sufficient criterion is to observe whether the two instantaneous axes of rotation intersect on the axis of the shaft.

If one of the raceways presents but a single surface, the instantaneous axis of rotation corresponding may be accommodated to the one determined by the other raceway. If both raceways present single surfaces, the instantaneous axes may be assumed—apart from compression considerations—as having desired direction. Accordingly, for *two-point* and *three-point* contacts, the question of conflicting axes of rotation does not enter. In fact, in the two-point case, the axis of rotation may be regarded as liable to fluctuation.

Let us return to Fig. 1. Relatively

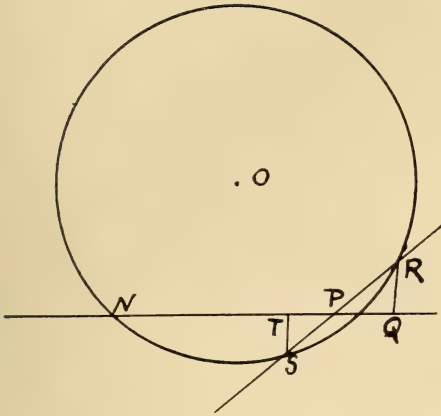


FIG. 2.—BALL CONTACTS

to the inner raceway there shown, the ball is momentarily rotating on NP as an axis. If the materials were absolutely structureless and incompressible, the contacts would be really points and no sliding abrasions would take place. But steel and all other materials must be regarded as undergoing local deformation. We have in consequence surfaces of contact instead of points. Assuming that the contacting portions are similar in section to what we have in an exaggerated form in Fig. 2, we shall readily see that rotation on NP will really mean that S and R , on the ball, are rotating with TS and QR as radii. In consequence, there is a sliding of metal on metal. The radius of rotation is at a maximum at S and R but possesses some value,

even though a less one, for intermediate points (except P). A little consideration will show that this is a very serious source of friction. It is a slide under pressure. We may, I think, safely assume that, despite the reduction of the intensity of pressure at individual points, the increase of the area of contact means increase in the aggregate of sliding friction. Usually, however, increase in area is a consequence of the increase in pressure. The effort of the designer should consequently be directed towards reducing this area to a minimum. Imagine one ball in a sharp groove and another in a blunt one. See Fig. 3. It is evident to any one that the friction developed by rolling under load is very different in the two cases. There is a clear reason for this. Assuming the vertical loads to be the same, the pressures between ball and raceway are much greater in the case of the sharp groove. Because of the greater pressures, the areas of contact will be larger, so that, when rotation on the instantaneous axis occurs, an increased total of sliding friction will be developed. Now the things the designer should seek are, (1) low pressure, and (2) small angle between instantaneous axis and profile of contacting surface. Evidently, the higher the pressure, the greater the area involved in slide. As to the second point—we shall readily see by returning to Fig. 2, that with the same pressure and con-

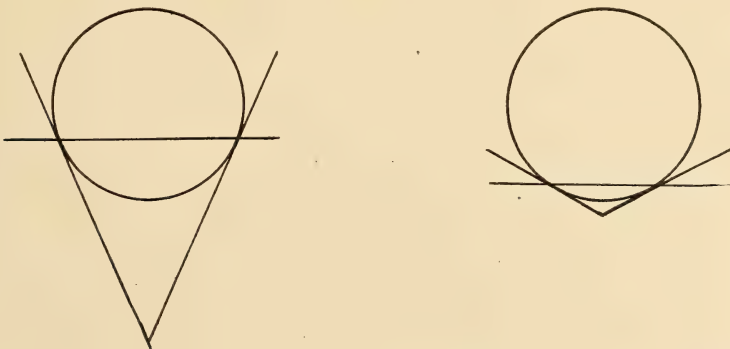


FIG. 3.—SHARP AND BLUNT GROOVES

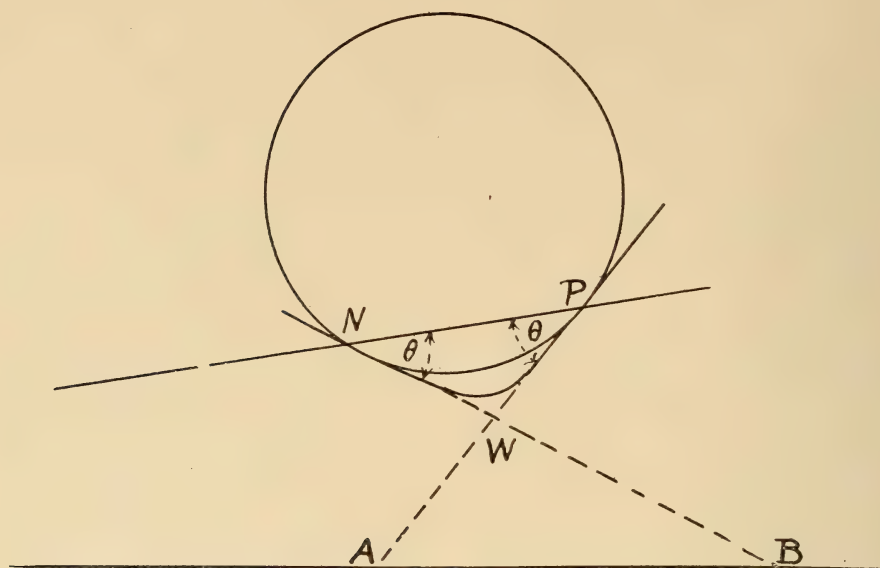


FIG. 4.—ANGLES OF GROOVE PROFILES

sequently the same length SR an increase in the angle RPQ will lengthen all the radii of rotation like QR and TS . In Fig. 3, the friction of slide with the sharp groove is still further increased by the augmentation of the angle between instantaneous axis and raceway profile. The question of the size of this angle is a vital one in ball bearings. It is clearly the larger factor accounting for the excessive difference between the cases of Fig. 3. In the second view, a doubling of the pressures along the common normals at the contact points would of course increase the areas of contact and thus augment the sliding friction. But all radii of rotation would be small and the increase in friction would be only moderate. We see, then, that the increase in normal pressures in the first view due to the steepness of the groove faces being only moderate itself could give rise to only a moderate increase in friction. But one needs but very little experience to know that the actual difference between the two cases is excessive. So that we conclude that the influence of the angle between

groove faces and instantaneous axis is profound.

Consider Fig. 4. Let A and B be the angles made with the axis of the shaft by the groove profiles. Denote by θ the equal angles APN and BNP . We have, from the triangle AWB and NWP ,

$$2\theta = A + B$$

$$\theta = \frac{1}{2}(A + B)$$

It is this angle which we wish to keep small. The same formula applies for the outer raceway. Now the only way to keep θ small is to minimize both A and B . We derive, therefore, the general rule that all groove face profiles must make small angles with the shaft axis. We can, of course, make A and B quite unequal. But neither may be other than small. If we adopt the small angle 15° as a maximum value, we may have such outer profile angles as 20° and 10° , corresponding to $\theta = 15^\circ$; and inner ones as 16° and 6° , corresponding to $\theta = 11^\circ$. Such angles as 11° and 15° we may regard as having but little frictional effect.

If the balls have two-point contact, as in Fig. 5, the instantaneous

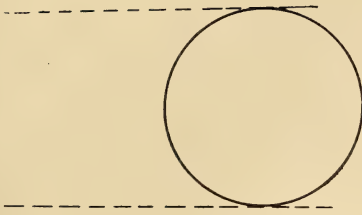


FIG. 5.—TWO-POINT CONTACT

axes are indeterminate, apart from considerations of compression and the like. If we consider a point of contact as really made up of two nearby points, we would conclude that the instantaneous axes are really prolongations of the groove profiles. These are necessarily parallel. Conse-

quently, their intersections with the shaft axis cannot be identical—except in the special case when all three lines are parallel. There will, therefore, be a conflict of the two axes of rotation thus separately determined. The instantaneous axes will consequently be displaced towards each other so as to intersect on the shaft axis. We shall have, therefore, $\theta_1 > A$ and $\theta_2 < A$. To consider the frictional consequences we regard θ_1 and θ_2 as the same and equal to A . We thus reach the conclusion that A must be kept small—say, not more than 15° . Those familiar with some of the old two-point bicycle designs will see at once that this rule was grossly violated.

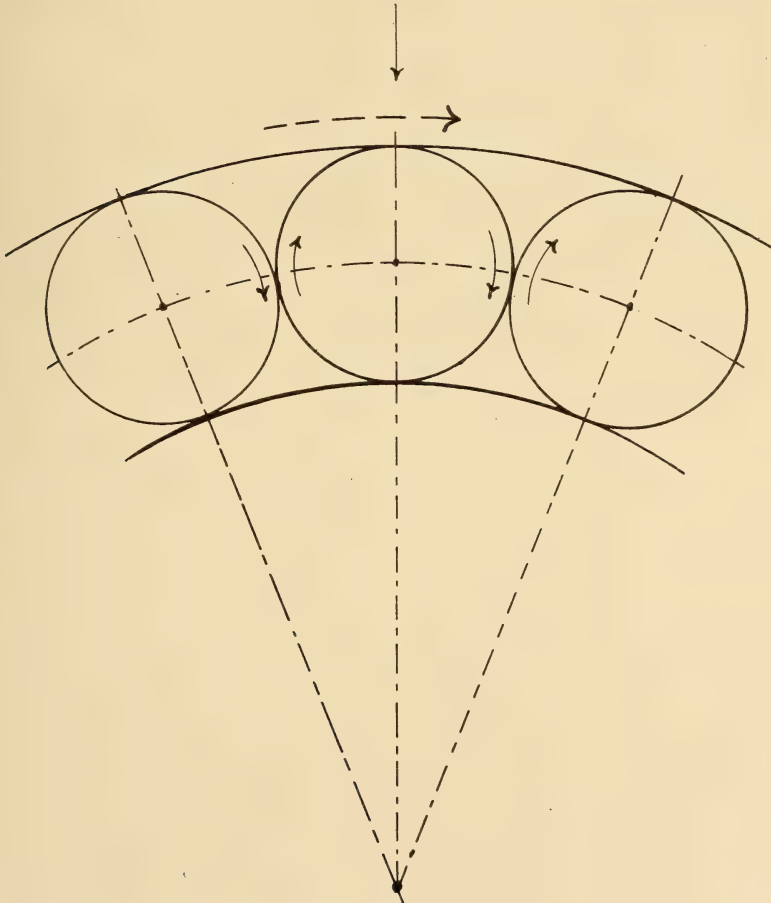


FIG. 6.—SLIDING ACTION OF CONTACTING BALL SURFACES

The value $A = 45^\circ$ may, perhaps, be regarded as typical of the practice. The friction would doubtless have been terrific, if the loads had been considerable. With the insignificant weights and very hard surfaces, the compression was slight and consequent friction moderate.

We have now considered three sources of friction in ball bearings—rolling proper, conflict of instantaneous axes and the slide induced by compression. There remains a fourth source—the contact of ball with ball. A consideration of Fig. 6 will make it clear that contacting ball surfaces are moving in opposite directions. This might, however, be of no importance, if the pressure between balls is negligible. The question of this source of friction turns therefore upon the amount of pressure. With outer and inner raceway concentric and with incompressible material, there would be no pressure between balls. The outer raceway will deliver its pressure along the common normal which passes through the raceway and ball centres. The pressure between ball and inner raceway will likewise pass through the centres of the two. With both raceways perfectly concentric and steel incompressible, these lines of pressure would coincide with the result that the ball would be thrust neither backwards nor forwards. But

these conditions are not realized in practice. The eccentricity due to radial clearance may be regarded as negligible with the best bearings. But with compressible steel, the coincidence of raceway centers is lost. For the case shown in Fig. 6, the consequent lowering of the centre of the outer raceway would seem to have a tendency to separate the upper balls from each other. There is, however, another consideration to be taken into account. Compression brings the balls in towards the shaft centre. Their centre move is, therefore, along converging radii. However, they do not come in equally because of unequal distribution of the load. We have scarcely space to discuss the distribution of the load over the few balls which receive it. Suffice it to say that it seems probable that when a ball receives its maximum, it receives nearly the whole of the load. In this position it would consequently be forced in further than the balls front and back. This would have the effect of shortening the distances between centres still further. There are thus two causes operating to force the balls distinctly together, and one which tends perhaps to produce a slight separation. On the whole, it would appear that balls that would be in contact, apart from compression, will be pressing each other in consequence of compression.

(To be continued.)

DIAGNOSING AN INDUSTRIAL DISEASE

By H. F. J. Porter

THE PATIENT

PROBABLY very few people realize the great change that has taken place within a comparatively few years in the business complexion of New York City. Fifty years ago it was still a commercial and residential seaport. Some of its leading citizens of to-day can recall their early homes at the Battery and lower Broadway, and the importing and exporting houses of their fathers, on either river not far away, interspersed with an occasional ironworks, where the repairs to the ocean vessels and harbour craft were performed.

There was very little manufacturing done outside of that which was necessary for the self-maintenance of the city. Broadway above the City Hall as far as Twenty-third Street was lined with stores, and the cross and parallel streets were filled with residences. Above that was suburban property, thinly settled.

The West Side embraced Greenwich, a small residential village. The East Side was occupied by the lodging houses of the newly arrived foreign element, which was just beginning to flow into the country, and, arriving at this gateway, lingered for a short or longer period until it could find its bearings.

THE INOCULATION

But as time passed and the city grew and its needs developed, a large proportion of this element found that it did not have to go elsewhere to secure work, and gradually the tenement-houses became workshops wherein were made the clothing for the people of the city, and, later, of the country.

This condition of affairs lasted for many years, until the "Great East Side," with its crowded sweatshop tenements, became a menace to the health of the city, and of the country as well, for the garments made there carried tuberculosis and other contagious diseases wherever they were sent.

TREATING A SYMPTOM

Then the authorities woke up and passed legislation forbidding these conditions to continue, and so the sweatshop workers were compelled to move into better quarters, which, as they had no money to procure, were provided by "contractors"—middlemen in labour, a new development—who rented rooms sometimes in a tenement under a license, sometimes in a larger building and gathering several workmen together, developed a workshop which offered better facilities and more wholesome surroundings than were previously furnished.

In 1890 the first steel skeleton loft buildings were erected in New York City, many of them being located on land which had the highest value, the tall building with many floors being the only kind of building offering sufficient floor area from which rental enough could be derived to pay a satisfactory interest on the capital invested.

Thus a movement was started which, beginning on lower Broadway, replaced the residences there and on the adjoining cross and parallel streets and continued farther and farther uptown, as fast as the demand for space such as these buildings supplied was created.

A PARASITE WHICH SPREAD THE CONTAGION

One element which helped along the movement was the land and building speculator. This man, selecting a particularly favorable site, would secure options on it, then make contracts with a sufficient number of manufacturing tenants to secure his venture. On the strength of these assets he would buy the property, mortgage it, and put up the building, then fill it with tenants and sell it; and this operation would be repeated in a continuous chain, and is still going on at a greater rate than ever.

Thus the demand has continued to grow and the supply has continued to be met, until this commercial and residential seaport has become a manufacturing city, with a zone of factories running up through its centre, while on either side of the city are the homes of the factory hands, and midway between the factories and homes are located the stores where the factory hands obtain their household supplies.

THE CITY A FERTILE FIELD FOR BREEDING THE DISEASE

Now to understand the attraction that brings to the city this manufacturing element, we must realize that the latter is confined to those trades which require very little equipment of machinery and which have very wide seasonal fluctuations, such as the clothing and allied industries. These people find as best adapted to their requirements the large loft, with plenty of window area and gas and electric light and power on tap, so that only what is used has to be paid for. They have only to go to the street to find the labour they need, and this they hire and discharge according to their requirements. It can readily be seen that such accommodations could not be obtained in the country.

THE DISEASE AND ITS SYMPTOMS

When it is understood that the busy season lasts for only two or three months in the spring and the

same period in the fall, and that there are some 250,000 hands in these factories at these times, and that in midsummer and midwinter two-thirds of them are turned out of the factories with about as much ceremony as the gas and electric light are turned out, it will be realized that the city has to absorb this unemployed element somehow or other. Take, for example, the cloak makers' industry alone. It embraces 2,000 factories, with an average of 40 employees in each. These, with their families, constitute an industrial community of some 175,000 people, men, women and children, which is comparable to a city of the size of Providence or Indianapolis. It can readily be appreciated, therefore, how serious is the effect upon the city when the greater number of the wage-earners upon whom these people are dependent are suddenly deprived of their sources of income.

Of course, there are some trades whose seasonal fluctuations dovetail into the others, so that a part of this horde is gradually re-employed; but still there is the great factor of under-employment, which lies at the root of the problems of poverty and vagrancy, intemperance, crime, gambling, prostitution, sickness and mortality, and necessitate our alms and workhouses, penal institutions, hospitals, morgues, and the charitable institutions, all of which are palliatives to the conditions which have been allowed to develop.

And, meanwhile, the city has found itself helpless to change these conditions, which have gotten beyond its control, and the industrial inundation continues to sweep unhampered still farther and farther up-town.

Until 1890 Fifth avenue held its own against this encroachment; but in that year, starting just above Fourteenth street, office buildings came in, offering the privileges and facilities of manufacturing, and, as the demand for this sort of space grew, the old residents gradually



FIFTH AVENUE AND SEVENTEENTH STREET, CROWDED WITH LOITERERS FROM THE WORKROOMS OF THE LOFT BUILDINGS AT NOON

yielded to the inducements offered in the shape of high prices for their land and their homes gave place to loft buildings.

SOME LOCALITIES MORE SENSITIVE TO ATTACK THAN OTHERS

Around Washington square, where Fifth avenue begins, and up to Fourteenth street, the old conditions remain, the current as it has flowed uptown, following probably lines of least resistance, having passed this section by; but above Fourteenth street, Fifth avenue, once "the finest residential street in America," is becoming a canyon of loft buildings.

The manufacturers in these trades seek the best they can get for their money. The advertising advantages of a location upon Fifth avenue they are fully alive to and strive to seize. Their letter-heads bear the statement, "Our goods manufactured on the premises," which impresses the out-of-town customer.

THE MORE SENSITIVE THE LOCALITY THE MORE VISIBLE THE SYMPTOMS

From the fact that these loft buildings provide no space in or about them for their occupants to go to during noon hours these people swarm out upon the streets, sometimes over 1,000 from a building, and it is estimated that the crowds which occupy the avenue between Fourteenth and Twenty-third streets from 12 to 2 o'clock amount to some 20,000 people, the greatest congestion occurring just between Seventeenth and Twenty-first streets.

There is attracted to this section also a great number of unemployed people who use it as a labour mart, waiting about the streets all day to be hired and to confer with the factory hands, who come out at noon, as to the probabilities of securing work. This section, where five or at most ten years ago during these hours, carriages could be seen standing in front of the private residences of the old New

York families and but a few pedestrians were using the streets, now resembles the mill sections of Pittsburgh or Lynn or the stock yards of Chicago. And this is only the beginning.

It is an orderly crowd, composed almost exclusively of men, mostly Hebrews and Italians, and as they stroll slowly up and down the street—for such a crowd cannot move fast—they eat their lunches, which they have brought with them, or which they buy from itinerant hucksters on the curb, and smoke cigarettes. There is much tobacco chewing and expectorating on the pavements, and ladies who, strangers to these conditions, have unwittingly gotten into the crowd while intent on shopping, have had their dresses ruined. Those living in the neighbourhood either shun the section at this time or use a vehicle.

SYMPTOMS ARE DANGER SIGNALS TO BE HEEDED

At first, the storekeepers and resi-

dents on the avenue remonstrated at being inconvenienced, either in the press, or to the city officials, or to the manufacturers, but without effect. It was retorted that these working people were perfectly orderly, were breaking no law, and were, in fact, merely enjoying their right as private citizens to walk upon the public streets.

When, at times, the congestion has become so bad as to block the sidewalk, the police have invoked the authority of traffic regulation laws and caused arrests, with, however, about as much effect upon the situation as taking away a few buckets of water from the pool formed about a bursted water main would have upon remedying the trouble. No one seemed to be able to reach the cause, which was a composite one, in which the manufacturer, the employee, the loft-building owner and the city were all involved.

About four years ago the property owners and real estate interests on



THE CONGESTED FIFTH AVENUE SIDEWALKS AT THE NOON HOUR

PLEASE NOTICE THIS.

1. Please co-operate with us in improving the conditions on Fifth Avenue, and the side streets adjacent thereto.
2. Please remember that anything which interferes with or obstructs the free movement of people along Fifth Avenue hurts you and hurts us.
3. Please remember that customers who are visiting Fifth Avenue, and buying from the shops located on it and the side streets, object to loitering, and to the sidewalks being littered with lunch, tobacco juice, etc., and to the show windows being obstructed from ready inspection when quickly passing the same.
4. Please remember that any act that hurts business, in the end hurts us all.
5. Please remember that we ask you to help us by stopping all loitering, not only because it is against the Law, but because it is a matter which concerns your interest, and our interest in every way, and interferes with the development of Fifth Avenue, and neighboring streets, and the maintenance of them along the best lines for all the inhabitants of the City.

THE FIFTH AVENUE ASSOCIATION.
NEW YORK.

AVVISO

1. Si desidera che tutti cooperino con noi nel migliorar le condizioni di Fifth Avenue, e le adiacenti strade laterali.
2. Si ricordi che qualunque cosa impedisca o vieti il libero movimento della gente lungo la Fifth Avenue nuoce a voi ed a noi.
3. Si ricordi che agli avventori che visitano Fifth Avenue, e che fanno spese nei negozi posti in detta via o nelle vie adiacenti, dispiace vedere i marciapiedi ingombri di fannulloni, cosparsi di avanzi di refezioni, sporchi di sputo di tabacco, ed altro; come pure che le vetrine non possano essere prontamente osservate quando si passa alla svelta per le vie, e ciò perchè la vista ne è impedita.
4. Si ricordi che qualunque atto nuocia gli affari finisce per nuocere a tutti.
5. Si ricordi che noi richiediamo il pubblico che aiuti a porre un freno ad ogni vagabondaggio, non solo perchè esso è contrario alle leggi, ma perchè è cosa che riguarda sotto tutti i rispetti gl'interessi vostri e nostri, poichè esso impedisce lo sviluppo di Fifth Avenue e delle strade vicine, come pure il buon mantenimento di esse a beneficio di tutti gli abitanti della città.

THE FIFTH AVENUE ASSOCIATION.
NUOVA YORK.

מיר בעמען פאלגענדעס צו בעמערקען:

1. מיר לידען איין מיט אונז מיטאנאליטעט און צו פערבעסערען דיא לאגע אויף פי פים עוועניו. און דיא זייטען נאכען וואס פיהרען צו איהר.
2. פערנעמט ניט געפעליכט דאס אלעס וואס שטערט דיא פרייע בעוועגונג פון מענטשן איין דער פי פים עוועניו, שאדעט איין און אונז.
3. געדענקט דאס קינדען (ווייטערס) וואס קינדען פון פי פים עוועניו און קינדען פון פי פים עוועניו זאלן דאס און איהר דיא זייטען נאכען, ווייטען שטארק דאנען וואס מאכט מענטשן דרעקען זיך דארט ארום שלנג און שלנג דיא פראסאקען ווייטען אנגעוואפען מיט קעניגלעך מאכאנאמס. א. א. און דאס דיא מאנאליטעטס וואו דיא ווארע איז אויסגעשטעלט, ווייטען פערשטעלען, זא דאס ווען מען געהט שטעט פארביי קען מען ניט גוט בעמערקען די פערשטעלעטע שטעלען.
4. פערנעמט ניט געפעליכט, דאס אלעס וואס שטערט געשעפט, שאדעט אונז אלעמען אס ענדען.
5. געדענקט געפעליכט, דאס מיר בעמען איין אונז צו העלפען צו מאכען אן ענדע פון שלנגאנאדעלענע ארסידרעקען זיך אין נאס, ניט נור ווייל עס איז גענען דעם געזעץ, אבער אויך דערפאר וואס עס איז א זאך, וועלכע ריהרט אן אייער און אינער אינסענעס און יעדער הינזיכט און שטערט דיא ענטיקלונג פון פי פים עוועניו. און דיא בענאכטארעט נאכען, און דערלאזט ניט דאס מען זאל זיי אויפהאלטען אויף דעם בעסטען ארם מיר אלע אינאנאנער פון דער שטאדט.

THE FIFTH AVENUE ASSOCIATION

ניו יארק

NOTICE ISSUED BY THE FIFTH AVENUE ASSOCIATION, NEW YORK

the avenue, feeling the necessity of uniting for the purpose of bettering their general condition, and realizing their helplessness as individuals in endeavoring to solve a problem such as this, which was plainly within the province of the city officials, formed the Fifth Avenue Association, "an American village improvement society, the largest of its kind," and

have been endeavouring since then to ameliorate the conditions, and with considerable effect. The main obstacle which confronted them was the inaccessibility of those who were contributory to the cause. Each of the many thousand manufacturers stated, truthfully, that he could do nothing effective unless the others co-operated; but, as they were in no way as-

sociated, so as to be reached in a body, no concerted action on their part could be secured. The situation was the same with the loft-building owners. The only element that could be reached at all was the employee, who, belonging to the trade unions, could be reached *en masse*; but he, being simply the water in the main, was practically helpless, except that he could, perhaps, be assisted to flow away from the locality. However, the various trade unions responded with a genuine sense of realization of their contributory relation to the trouble, and, as a result of printed notices in various languages, which the unions posted in the shops, and of talks given at union gatherings, some betterment of conditions was effected. Through their acquiescence, also, some sixteen special policemen have been assigned to this section every day for the sole purpose of keeping the crowd moving.

GETTING BACK TO FIRST CAUSES

Seeing the great advantage which was inherent in having the various interests organized so that not only could each attend promptly and efficiently to those matters which affected it individually, but could offer an avenue of approach by which other interests which desired to confer with it on interrelated interests could reach it, the Fifth Avenue Association has been endeavoring to get the other contributory factors in the problem organized similarly to the trade unions.

There had been an association of manufacturers of clothing to which several hundred members belonged, but it had disintegrated during a succession of strikes about the time when the Fifth Avenue Association approached it. However, a new association has been recently formed, and, as a sequence of the settlement of the recent cloak-makers' strike, there have been formed certain standing committees, composed of representatives of this association and of the unions and the public. Thus has been

opened an avenue of approach to another of the principles which are largely contributory to the trouble in hand and which can do much to relieve it, if it will exhibit as cordially co-operative a spirit as the unions have.

The other elements are the loft-building owners, and the city and the first of these, the Fifth Avenue Association, is now endeavoring to persuade to similarly organize and the second to recognize that this is now an industrial city, and, therefore, it ought to establish a Bureau of Industry, which would supervise the growth of its industrial interests so that they shall not run amuck among the other and older interests, to their injury, and perhaps occasioning a permanent effect upon the topography of the city entirely without having its bearing upon the future of the latter considered.

For as this movement has advanced uptown the conditions which have accompanied it have depressed the price of real estate; and yet it is felt to be only a transitory symptom of an industrial disease which, as it passes, leaves a blight, the effect of which may only be conjectured.

It is a well-known law that evils, if allowed to run their course, become so gross as to effect their own cure; but it is also known that it is an obsolete and very expensive remedy, often resulting in the complete destruction of the elements which are affected. Those who have studied the trend of New York's growth say that before long the increase in land values on Manhattan Island will preclude the possibility of manufacturing within the city limits altogether, and that already large manufacturing districts are developing on Long Island, in the Brownsville district, and elsewhere. The question naturally arises to what use will these loft buildings then be put. Are they to be deserted absolutely or are they to be filled up by a more or less desirable type of tenant? The more modern method of

eliminating evils is by prevention, and this is recognized as the efficient method—and efficiency, our political economists tell us, must be the basis of our national progress for its continued and permanent success. Meanwhile, however, something has to be done to alleviate the present distress.

TENTATIVE PALLIATIVES

It has been proposed that the employees in each shop go out to eat their lunch at different hours, the cutters at 11:30 to 12:30, the finishers 12:30 to 1:30. This would cut the congestion in half.

It has been proposed to put reading, recreation and lunch rooms on the roofs of the buildings where the street hucksters can be taken, or to fit up lunch accommodations in the shops, where the employees can get free coffee and tea furnished by the employer. This provision is known to be a paying investment, as thereby a light stimulant would be substituted for whiskey and beer, which make the employees drowsy in the afternoons. In this way, also, the congestion would be further reduced.

It has been proposed that an employment bureau be established in a building on one of the adjacent parks, thus withdrawing the unemployed element completely from the neighbourhood of Fifth avenue.

An elevated sidewalk at the level of the second story of the buildings has been proposed as a possible remedy, a permanent feature to be adopted elsewhere as the street congestion of the city develops. Attention

has been called also to an underground Public Comfort Station recently constructed in Genoa, Italy, containing an arcade promenade on either side of which are located reading rooms, lunch rooms, library, baths, etc. Many other suggestions have been made, each of which, if carried out, would help to mitigate the situation, and all of them together would very materially serve to relieve it.

CALLING IN THE SPECIALISTS FOR A CONSULTATION

The Fifth Avenue Association is holding a series of conferences with representatives of the city government, and Borough President, and the manufacturers, and the unions of the employees who occupy them, and the Board of Control, composed of representatives of the manufacturers, the unions and the public; also, the Borough President and representatives of the city government and State Department of Labour. These, together with representatives from such civic organizations as the Citizens' Union, the City Club, the Mayor's Commission on Congestion of Population and the Legislative Committee on Unemployment, the National Employment Agency, and such industrial and social experts who are equipped to shed light upon the problem, will, it is expected, be able to develop a constructive policy which will not only remedy the present evil, but prevent a recurrence of it and similar ones in the future.

(The results of these clinics will appear in a later issue.)

INDUSTRIAL WATER SUPPLIES

A PAPER PRESENTED BEFORE THE LOUISVILLE ENGINEERS AND ARCHITECTS' CLUB

By J. C. Wm. Greth

WATER is the most abundant of all substances which make up our universe. It is also the greatest solvent. In domestic uses and industrial processes it performs functions second to no other substance. Its greatest solvent power accounts for its rarely, if ever, being found pure.

In its passage to the earth as rain it absorbs carbonic acid, which enables it to dissolve certain salts of lime and magnesia. It also dissolves other substances from the rocks, soil, vegetation, sewage, and industrial waste with which it may come into contact.

In addition to its solvent power it also has the power of mechanically carrying particles of matter in suspension. Suspended matter in water is unsightly and objectionable for domestic uses, and in industrial uses seriously affects the purity of the products. The soluble impurities may also be of such a character as to render it unfit for domestic uses, and in industrial uses cause waste of materials and inferiority in products.

In the steam boiler both the soluble and insoluble impurities affect to a large extent the cost of maintenance and the economy of steam production.

To the engineer and architect aiming at economical operation and low maintenance expenses for power plant and fixtures, the quality of the available water is an extremely important factor, since it affects the economy of the steam plant in large buildings, hotels, power houses, etc., causes a waste of soap in laundries of hotels, produces deposits in pipe lines and causes corrosion of expensive piping systems.

The impurities in water used for boiler feed affects to such an extent the generation of steam that it becomes a subject of prime importance to anyone who has to do with the design or operation of a steam boiler plant.

The waste and expense due to bad feed-water are not confined to the boiler, for feed-water heaters must be clean to obtain from the exhaust steam the maximum temperature.

Pipe lines clog and fill with scale. If surface condensers are used and bad water is used for condensing, the condenser must be cleaned, and even if the water obtained by condensing the steam is used as boiler feed, make-up water of poorer quality is necessary, and while this is diluted to a great extent, it still gives trouble in the boilers.

Oil in the condensed steam is also an item requiring consideration, as the complete elimination of oil is essential for the best results in the boiler, especially so when the steam is to be used for cooking purposes and when steam is used in connection with the preparation of food.

With turbine engines oil is usually not a factor, as none is used; but superheaters are often called into service, and many problems arise for which the impurities in the feed-water are responsible.

In the refrigerating plant the ammonia and steam condensers become scaled, and when ice is manufactured from the distilled water made from the exhaust steam the quality of the ice is often affected by the impurities in the water.

In the modern building the plumbing is a large part of its cost, and

when bad water is used the renewal of both hot and cold-water piping and fixtures becomes a large item of expense. Corrosion and scale are more frequently found in the hot-water piping, but there are some few cases of these same effects from cold water.

It is readily understood that the solubility of some of the impurities in water is reduced by heating, thereby causing scale and the liberation of corrosive acids. Scale and corrosion with cold water, or only that rise in temperature due to the temperature in the building, is not quite so evident. Agitation caused by pumping and otherwise disturbing the water causes some of the dissolved carbonic acid to escape, thus producing a precipitation of lime and magnesia. The carbonic acid liberated often causes corrosion.

Well waters often contain impurities that prohibit their use without filtration or softening. It is quite common in some sections to obtain a perfectly clear water from a well, but, after agitation, it turns brown, discolouring everything with which it comes in contact; other well waters turn brown by aeration; some have a disagreeable odour; others, an unpleasant taste, which disappears after agitation and aeration. Some of the well waters having the peculiarities just described are perfectly soft, the only objection to their use being the qualities noted; on the other hand, many well waters that are quite hard also have these same peculiarities.

The larger hotels are usually equipped with laundries. Here, to a considerable extent, impure water enters into the cost of the work and the life of the goods laundered. This is of especial importance when the goods laundered are largely owned by the man who runs the laundry, since he is directly interested in the life of the linen, etc., and is not quite so careless on this point as the average laundryman, who does not, as a rule, replace the goods worn out in laundry processes.

The first question that comes up in deciding on a water supply for any building is, naturally, that of its quality for drinking purposes, the considerations being appearance, odour, taste, and, finally, its organic purity. The city supplies are generally used, and, in some cases, from a sanitary standpoint, are satisfactory.

In nearly all buildings, however, mechanical filters are installed, usually of the pressure type, which are supposed to fit the water for any and all uses. It should, of course, be understood that all any filter can do, whether of the gravity or pressure type, is to remove from the water its suspended impurities. If the filter area is large enough and the suspended matter in such a form that the filter bed can intercept it, the water will be said to have been properly filtered. To make these filters effective, a coagulant is employed, generally aluminum sulphate. If the water contains sufficient alkalinity—and most waters do—the aluminum hydrate formed by the alum, combining with the temporary hardness of the water, coagulates the finely divided suspended matter into such a form that the filter will remove it. This will improve its organic purity, as well as its appearance, and, with a properly designed and operated filter system, a water satisfactorily from a sanitary standpoint is obtained.

The water, however, for boiler feed and all other uses has not been improved; in fact, for boiler feed the permanent hardness of the water has been increased by an amount corresponding to the quantity of the alum used.

It must not be understood that the total hardness is increased; there is simply a change in the nature of the hardness from temporary to permanent, or in this case, from carbonates to sulphates, the amounts of the lime and magnesia salts remaining the same.

The efficiency of the power plant of the modern office building or hotel—in fact, of any power plant—

is dependent upon the character of the water used for boiler feed.

Steam generation is a continuous process, fresh feed-water being supplied to the boiler as the water, evaporated into steam, leaves it. This results in a continual concentration of the impurities introduced with the feed-water.

This concentration produces an increase of suspended matter, scale, corrosion, and an increased density of the boiler water. Of these, the most important are scale and corrosion. That scale and corrosion in the steam boiler, especially in a large building, are a hindrance to safe operation, not to mention their effect on the economy of operation, is self-evident.

It is also essential that the power plant occupy a minimum of space, and that it operate twenty-four hours a day, every day in the year. Under these conditions scale and corrosion are to be more feared than under more favourable operating conditions.

The fear of the expense and danger is shown by the large number of manufacturers of boiler compounds, purifiers, cleaning machines, skimmers, filters, etc.

Scale can nearly always be attributed to the lime and magnesia salts in solution in the water. The character of the scale depends upon the acids combined with the lime and magnesia, on the type of boiler in use, and on the rate, temperature and pressure at which the boiler is operated. For instance, the carbonates of lime and magnesia, which cause the temporary hardness, when present alone, usually form a soft scale. The presence of calcium sulphate sometimes increases its hardness. A calcium sulphate scale is generally quite hard.

Corrosion is usually due to the acids introduced into the boiler in the feed-water, or to those resulting from reactions between the various substances in solution, under the influence of pressure and concentration.

The different acids cause different kinds of corrosion, and it occurs in different parts of the boiler, depending upon the nature of the acid.

Many of the methods and devices brought upon the market by the prevalence of scale and corrosion are irrational in application.

The willful introduction of any substance which does not form steam into a boiler results in an increase of impurities in the water. By such methods, therefore, the boiler incidentally becomes an accumulator for both the impurities of the feed-water and the substances introduced to prevent the adherence of the scale.

Under the most favourable conditions all that the most effective boiler compound can accomplish is to change the nature of the precipitate from one which adheres to the boiler to one which will be carried in suspension in the boiler water. To overcome corrosion, boiler compounds are, as a rule, effective, because they are usually alkaline and neutralize the acids, provided, of course, a sufficient quantity is used and that it is adapted to the particular water supply. Many compounds, however, are made up with corrosive agents, and are in themselves the cause of corrosion.

A method employed by many engineers for attacking the feed-water problem is that of having the scale deposited in some auxiliary apparatus, such as a feed-water heater.

It is a known fact that raising the temperature of water reduces the solubility of some of the salts in solution; but, in the opinion of the writer, this does not justify the use of the heater to bring about such a precipitation for purifying feed-water.

Heating water for its purification may be divided into two stages: First, to the boiling point, at atmospheric pressure, in the attempt to remove the temporary hardness; second, from the boiling point to the temperature of the water in the boiler, in the attempt to remove the

permanent hardness. This division is made because, in practice, exhaust steam is generally used for temperatures to about the boiling point and live steam for the higher temperature.

To effect the practical removal of the temporary hardness by heating, boiling for at least 30 minutes is necessary to bring about a precipitation of the carbonates of lime and magnesia to the limit of solubility. This can easily be proved experimentally. It therefore follows that, in heaters of this type, complete precipitation cannot be effected, on account of the short time at which the water is held at the temperature attained in it. Precipitation by heat is not an instantaneous process, but a gradual one, and the time the water remains in the heater is rarely sufficient to complete the precipitation.

To broaden the application of the open exhaust steam feed-water heater to include the removal of the permanent hardness, the size has been increased and provision made to introduce some softening reagent, usually soda ash. Since the amount of heat is not sufficient to remove the temporary hardness, on account of insufficient heating time having been allowed to accomplish the removal of the carbonic acid which holds the carbonates of lime and magnesia in solution as bicarbonates, the carbonic acid remaining combines with the soda ash added and forms sodium bicarbonate. This will not react in the heater with the substances which make up the permanent hardness, and, therefore, unless sufficient soda ash be added to take up all the unexpelled carbonic acid in addition to that required to react with the permanent hardness, complete precipitation of the salts of the permanent hardness cannot take place in the heater.

The addition of the requisite soda ash to produce complete precipitation in the heater purifier means an excessive and expensive treatment. So far as the ultimate results are concerned, the soda ash might as well be

introduced into the boiler without the danger of corrosion from the action of the nascent carbonic acid, resulting from the decomposition of the bicarbonate of soda.

Any attempt to make a feed-water heater of either the open or closed type perform two separate functions is merely a makeshift, since, as its efficiency as a purifier increases, its efficiency as a heater diminishes. The mere fact that scale is deposited in a heater does not justify its being called a purifier, any more than to call a boiler a purifier because scale deposits in it.

There are many other mechanical and chemical devices on the market whose basic theories may be correct, but their application for the purification of feed-water for boilers does not bring about the desired results. As is well known, the direction of efforts upon the effect rather than against the cause is not attacking the feed-water problem in the rational way. The more any apparatus whose proper function is to impart heat to water is used as a scale collector, whether this be heater, condenser, or boiler, the less will be its efficiency as a heat conductor.

To overcome the effects of hard water in the laundry, the waste of soap being secondary, washing soda, bleach and acids are employed to give the goods the proper colour. The cause of nearly all trouble in obtaining results with hard water in the laundry may be briefly stated, as follows:

Hard water prevents the formation of the emulsion of soap and water, and when this occurs the dirt cannot be so effectively removed from the goods. Hard water also causes the formation of the sticky curds of lime and magnesia in the fibre of the goods, which cannot be removed even by rinsing.

Furthermore, the soap will not begin its work until all the lime and magnesia salts have combined with the soap; therefore, the soap does not act quickly, and that part which

combines with the lime and magnesia is wasted. The amount of lime and magnesia soaps formed is proportional to the amount of lime and magnesia in the water. These soaps are insoluble and have no detergent action.

The washing process may be considered as a process of emulsifying the grease, which causes the dirt to adhere to the fibre of the goods. This grease increases the emulsion by forming a part of it. Inasmuch as the lime soaps are formed before the emulsifying of the grease in the goods can begin, the action on it is prevented to a great extent by the presence of the insoluble sticky lime soaps. In later processes, the presence of these lime soaps affect the appearance of many pieces which, in some cases, cannot be entirely overcome by bleaching or blueing.

After the washing with soap the goods are rinsed to remove all the soap and loose dirt still adhering to the cloth. If hard water is used in this operation, the soapsuds cause a new precipitation of the lime and magnesia salts.

These insoluble soaps lodge in the meshes of the cloth, making the fabric stiff and harsh, while at the seams and hems, or with heavy cotton and linens, the heat from the mangles and irons turn them gray.

The sudden disappearance of the soapsuds when rinsing with hard water is often given as a good reason for its use by laundrymen who are not familiar with the chemical reactions between the soap and lime and magnesia salts that cause the quick disappearance of the soap. The formation of the insoluble lime and magnesia soaps in rinsing is just as objectionable, or even more so, than in the washing process.

Bleaching with chlorine, prepared electrolytically from salt, or with bleaching powder, is the next operation, which is followed by the acid bath, for which oxalic, acetic, and, in some instances, sulphuric acid, is used. Oxalic acid is the one most

commonly used. If the water contains lime compounds, they are converted into fine crystalline insoluble lime oxalates, which, if precipitated in the fibre, cannot be removed by either hot or cold water. This makes the clothes feel harsh, and may even start a cutting of the fibre.

Then follows the blueing, which is generally added to the acid bath. All clean white goods are yellow when held to the light; hence, to make them appear white, blue is used—in other words, to cover the yellow and to effectually give the goods the desired white it is essential that the surface to be blueed be uniform in texture, for any irregularity, due to foreign substances in the fibre of the cloth, results in unevenness, or, in other words, spots or streaks.

The waste of soap is no small item.

Thus, in a river water, containing 4.25 grains of calcium carbonate and 2.34 grains of magnesium sulphate, the waste of soap due to the lime and magnesia salts is 9.8 pounds per thousand gallons; while in a well water, containing 17.86 grains of calcium carbonate and 11.16 grains of magnesium sulphate, the waste of soap rises to 39.5 pounds per thousand gallons of water. It is thus evident that soap is a rather expensive material for softening water.

This soap waste does not stop in the laundry, but in the general cleaning about the building, bathtubs, washstands, etc. The iron and lime leave a stain which cannot be removed except by scouring with some abrasive material. Further, using hard water for bathing purposes destroys, to a large extent, the feeling of soft skin and cleanliness that follow the use of soft water.

It will appear evident to anyone at all familiar with the use of water in a power plant or in the manifold uses of the hotel or large building of any kind that the impurities in water should be thoroughly considered, as they are of considerable importance in relation to maintenance and operation.

The remedy does not lie in make-shift methods or covering over of the impurities and the troubles caused by them, but in the actual removal from the water of those substances which cause waste and annoyance and interfere with the functions of the water.

The remedy lies in the softening and purifying of the water, which is a rational and thoroughly demonstrated method, and which meets every requirement and overcomes the difficulties chargeable to the impurities in natural waters.

The process of softening and purifying the water deals with the problem in the manner prescribed by the chemist, by the use of proper reagents, which will neutralize corrosive acids and change the soluble salts of lime, magnesia and iron into the insoluble precipitates, which can be removed by sedimentation and filtration.

The reagents in general use for the softening of water are lime and soda ash. Other substances are used, depending upon the nature of the water and the purpose for which it is to be used. Lime and soda ash, however, meet the requirements in most instances, and are the cheapest reagents known to the chemist for accomplishing the softening and purifying of water. The proper softening and purification of water can be accomplished only in apparatus designed with all the chemical and mechanical requirements kept in view.

The impurities in a water of average hardness—say 20 grains per gallon—only represent about 0.04 of 1 per cent. by weight. This being the case, it is of vital importance that an exact weight of reagents be introduced in a measured volume of water. This is particularly necessary

in a hotel or public building where the water is to be used for every purpose.

The operation of a water-softening system requires only the exercise of common sense and ordinary care. It is possible with a properly designed and operated system to eliminate or neutralize any acid, to completely remove all permanent hardness, and to reduce the remaining temporary hardness to less than three grains per U. S. gallon, and to produce a clear effluent.

Any system which fails to give these results is either faulty in design or improperly operated.

That a water must be clear is self-evident, and to absolutely insure obtaining a clear water every water-softening system should be equipped with a quartz filter, which can be thoroughly washed by reversing the flow of water through it.

The installation of a water-softening system in a building with the idea that any water-softening system is better than none is only partially relieving conditions, and is not effecting the economy obtainable on the basis of installing the system which best meets the requirements for the proper softening, purification and clarification of the water.

The proper softening and purification of water will prevent the formation of scale in heaters, pipe lines, boilers and all auxiliaries that may be used in the building with which the water comes in contact. It will prevent the discoloration of plumbing fixtures; also, prevent deposits in them due to the lime and magnesia curds from the soap used, as well as prevent the waste of soap in the laundry; it will, in fact, prepare the water to meet every requirement, mechanical, domestic, and for drinking.

SCIENTIFIC TOURING

By M. B. Cea

THE imagination of Jules Verne failed to conjure up any probabilities of travel which have not been more than realized in the past fifty years. A description of the mechanical perfection and luxuries of a modern ocean liner forms a worthy sequel to his most fanciful tales. Phileas Fogg, it will be remembered, circled the globe in eighty days, traveling at breakneck speed, and enduring many hardships. To-day a tour of the world may be made aboard a floating hotel in but little more time, while enjoying the luxuries and protection of devices undreamed of by Jules Verne. About 110 days are now allotted to the trip, but of these only 78 days are spent in actual travel in encircling the globe.

The cramped and poorly-lighted cabins of Phileas Fogg's day have undergone a marvelous transformation. Every luxury of equipment, every art of the decorator, has been employed in the modern vessel. Although half a thousand passengers are to be carried around the world, the vessel in which such a tour is effected is absolutely self-centered and independent of ports of call. The comfort of passengers is insured in all extremes of weather, whether nearing the Arctic circle or at the equator.

The genius of the inventor is apparent in every detail of the equipment of the great ship, especially in connection with the provision of absolute safety at sea. By a complete system of electrical communication, comparable to the nerves of the human body, every part of the ship is kept under the immediate control of

the commanding officer. Behind the ornate panels of the cabins and beneath the carpeted floors there runs a system of automatic communication which never sleeps.

The problem of the work of the steward of such a ship is far more complicated than is imagined by the landsman. To keep this floating hotel in operation under all conditions he must utilize every inch of space. The kitchen of such a vessel as the *Cleveland*, for instance, capable of catering for 500 passengers, is a marvel of convenience. Ingenious mechanical devices are called upon to relieve the ordinary drudgery of the kitchen. Here are found electrical cooking devices, automatic egg boilers, mechanical dish-washers and driers, vacuum cleaning devices, and other labour-saving apparatus.

The term "son of a sea cook" is no longer a title of reproach. The highly-paid specialist who presides over the kitchens is a chef with an international reputation. The menu at the end of the longest sea voyage gives no indication that the ship has not been supplied from land. Immense stores of fresh meats, vegetables, fruits, and even flowers, must be carried. Far below may be found a variety of cold storage rooms, in which the temperature is kept automatically at the proper point, entirely independently of the latitude observed from the bridge.

The kitchens are incredibly clean, with their tiled floors, glass tables and shelves; as are also the cold storage rooms. To keep a kitchen in order is a far more difficult problem at sea than on land. The storage of the delicate china and the silverware

alone is an interesting question, since these must be stored in ingenious racks, within the smallest possible space, and protected against the motion of the ship.

The anxieties of Phileas Fogg throughout his famous world tour might have been removed in a few minutes by the use of the wireless telegraph, which keeps the modern globe-trotter continuously in touch with affairs on land. The steamer keeps to its schedule more closely than the average railway train, and an appointment may be made at any point of the trip with confidence. Neither is there any trouble over international banking questions, since the steamer carries its own bank, at which travelers may exchange their money for the coin of any of the countries visited.

For passengers accustomed to outdoor life the modern steamer brings no sense of confinement. The mechanical gymnasium, which forms a part of the equipment, enables one to take long rides either on horseback or on camel. Every set of muscles in the body may be exercised by the use of these ingenious devices without effort or expense. Arriving in port, the passengers find that every possible preparation has been made

for their convenience and pleasure.

Extended trips are planned inland, and the tourist of the *cruise de luxe* passes around the world, through a babel of different tongues, without the slightest inconvenience. The completeness with which every detail of travel has been arranged in advance is illustrated by the side trip prepared to Damascus. Formerly this journey necessitated a wearisome trip across the desert by caravan. To-day the tourist is carried to the sacred gate of Damascus, across the desert, by a swift automobile in a few hours.

The surprising variety of the equipment of a great ocean liner robs the longest voyage of its tediousness, even in the tour of the world. For those athletically inclined there are a variety of games to be played in the gymnasium and on the broad decks. The library is well supplied with books in several languages. There is a flower garden for supplying the shop of the florist, while a small truck patch enables fresh berries to be picked throughout the voyage.

One of the events of the day, in good weather, is the sea bathing in a large tank on an upper deck. As the ship rolls under the action of the waves, one may enjoy a very good



A HAMBURG-AMERICAN LINER OF THIRTY YEARS AGO



STEAMSHIP CLEVELAND. HAMBURG-AMERICAN LINE

imitation of surf bathing. In addition, there are Turkish baths, electrical baths and therapeutic baths.

The trip around the world this year will be made aboard the steamship *Cleveland*, of the Hamburg-American Line, sailing from New York on November 1, 1911. A second trip will start from San Francisco by the same vessel on February 12, 1912.

The *cruise de luxe* around the world, by a curious coincidence, follows very closely the route taken by

Phileas Fogg in his famous trip. A score of notable ports are visited, and in some cases nearly a week is allotted for sight-seeing and inland trips. The total distance covered is 22,613 miles, a valuable short cut being afforded by the Suez Canal. Three years hence one of the greatest engineering enterprises of the world will be completed at Panama, after which the complete trip will be made by a ship, departing from and landing its passengers at the same pier.

Dr. Edward Weston, well known as an electrical engineer and inventor, was born at Brynn Castle, near Oswestry, Shropshire, England, in 1850. His education was originally directed toward the profession of medicine, but his strong inclination toward electrical subjects led him to abandon this intention, and to come to the United States, where he was first occupied in the industry of nickel-plating; and in 1872 he began his experimental investigations in the improvement of dynamo-electrical machinery. The extent of his labours in this field will appear when it is understood that during a period of eleven years there were issued to him three hundred patents relating to useful applications of electricity.

In 1886 the laboratory at Newark, New Jersey, was established, this having developed into the Weston Electrical Instrument Company, for the manufacture of the famous Weston electrical measuring instruments; his work in this field also including the Weston cadmium cell and the zero-co-efficient resistance alloy known as manganin.

Dr. Weston has been honored with the degrees of D. Sc., and LL. D., and was one of the seven notable scientists recently selected by the Franklin Institute to be given the Elliott Cresson Gold Medal for "distinguished, leading and directive work" in his especial field.

Dr. Weston is a charter member of the American Institute of Electrical Engineers, and a past-president of the same society, besides holding membership in many other professional societies in the United States and in Europe.



Photograph By Gessford, New York.

EDWARD WESTON, D. Sc., LL. D.

See Reverse Side.

INDEXED.

CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

Vol. XXXIX

MARCH, 1911

No. 5

INTERNAL COMBUSTION ENGINES AT THE BRUSSELS EXHIBITION

II.—OIL ENGINES.

By Percy R. Allen

THE internal combustion engines at the Brussels Exhibition using liquid fuel were classified in the same division as gas engines and gas producers and were included in Class 20, group 4, but Petrol engines for automobile purposes were considered separately under class 31, and will not be dealt with here.

Although internal combustion engines using liquid fuel are almost as old as the gas engine itself, a great stimulus has recently been given to the development of the heavy or crude oil engine by the discovery of large quantities of petroleum distributed in all parts of the world, and as many of these oil-bearing deposits are on or near the great trade routes, the use of fuel for ocean steamers has become not only a great convenience but a sound commercial proposition. Even where oil fuel is used simply, instead of coal, to generate steam under marine boilers, there are considerable conveniences in the way of saving in bunker space, in quickness and ease of replenishing supplies and greatly reduced labour in the stokehole, and these points of advantage become still more marked where it is burned directly in the internal combustion engine.

Various classifications of oil en-

gines have from time to time been suggested, and, broadly speaking, they may be divided into three classes, in one of which divisions come the engines using petrol, alcohol and the like; in this case the fuel is simply passed through a carburetter and taken over to the cylinders in the form of a cloud or vapour, the carburetter merely forming a mechanical mixture. In the second class, the fuel passes through a heated vaporiser and is more or less changed into a gas before it enters the cylinder, the vaporiser effecting a partial distillation; and in the third class, like the Diesel engine and its many modifications, the chemical transformation is effected entirely after the charge of oil is introduced into the working cylinder.

Although the Diesel engine would by no means come first in any historical account of oil engines, it may be convenient to refer to it here in the first instance, as so many modern oil engines now operate on the Diesel cycle, or variations of it.

Taking the Diesel engine built on the ordinary four-stroke system, the round of operations may be summarized as follows: First, the suction stroke. Assuming that the exhaust has been discharged by the beginning of the suction stroke, pure



FIG. 1.—INDICATOR DIAGRAM OF FOUR-STROKE DIESEL ENGINE.

air, alone, is drawn into the cylinder by the receding movement of the piston, whereas, on the Otto cycle, air and gas both enter at the same time, so that a charge of mixture already exists in the cylinder at the beginning of the compression stroke.

Second, the compression stroke. The pure air just drawn into the cylinder is then compressed by itself to something between 450 and 500 pounds to the square inch and attains a temperature varying between 900 and 1,000 Fah., corresponding to the degree of compression, but in any case considerably above the combustion point of the fuel oil.

Third, the power stroke. Just at the end of the compression stroke, and as the crank is turning the dead centre, the charge of oil is blown into the cylinder by an air blast at a pressure ranging from 700 to 800 pounds to the square inch. The ignition of the fuel at once takes place, but this action increases but little the pressure already existing in the cylinder. At the same time, so long as the injection of oil is continued, just so long is the pressure maintained, and some fully loaded Diesel engines give an indicator card with a flat top closely resembling that of a steam engine, the expansion curve only commencing when the admission valve closes.

Fourth, the exhaust stroke. In a four-cycle Diesel engine, during this stroke, the products of combustion are simply swept out into the atmosphere in the same way as in an ordinary gas engine. The cycle of operations in a four-stroke engine of

this kind can be clearly followed by reference to the indicator diagram, Fig. 1, in which the various strokes are numbered:

First stroke: Air suction (curve 0-1).

Second stroke: Compression, and thereby heating, of the air (curve 1-2).

Third stroke: (Working stroke) introduction of fuel, combustion, expansion (curve 2-2'-3).

Fourth stroke: Expulsion of exhaust gases (curve 3-4).

No ignition apparatus is required, nor is any preliminary heating of the combustion chamber necessary, as the compression of the air alone supplies the heat, and this heat is always sufficient to ignite the oil with absolute certainty as it is injected. Obviously, no pre-ignitions can take place, as no combustible is present in the cylinder until the oil is injected. On the other hand, there cannot be any back-firing, as the air blast prevents the ignition traveling backwards; and there cannot be any misfires, as the oil is bound to be burned at the temperature existing in the cylinder. Even when using a very common grade of crude oil, it all appears to be so perfectly burned that there is hardly any deposit found in the cylinders, and the exhaust at the same time appears to be quite clear. Governing is generally effected by giving the fuel-oil pumps a constant stroke, and by by-passing, or letting slip, a certain amount of the volume they displace, but every maker has his own particular device for this purpose.

Hitherto the majority of the Diesel engines have been of the vertical type, but some of the makers are now adopting the horizontal pattern, particularly in the larger sizes. The sectional view shown in Fig. 2 shows a standard four-stroke Diesel engine, having the compressor worked by links from the cross-head. The horizontal cam-shaft operation the various valves, which, in the vertical engines are placed in the cylinder

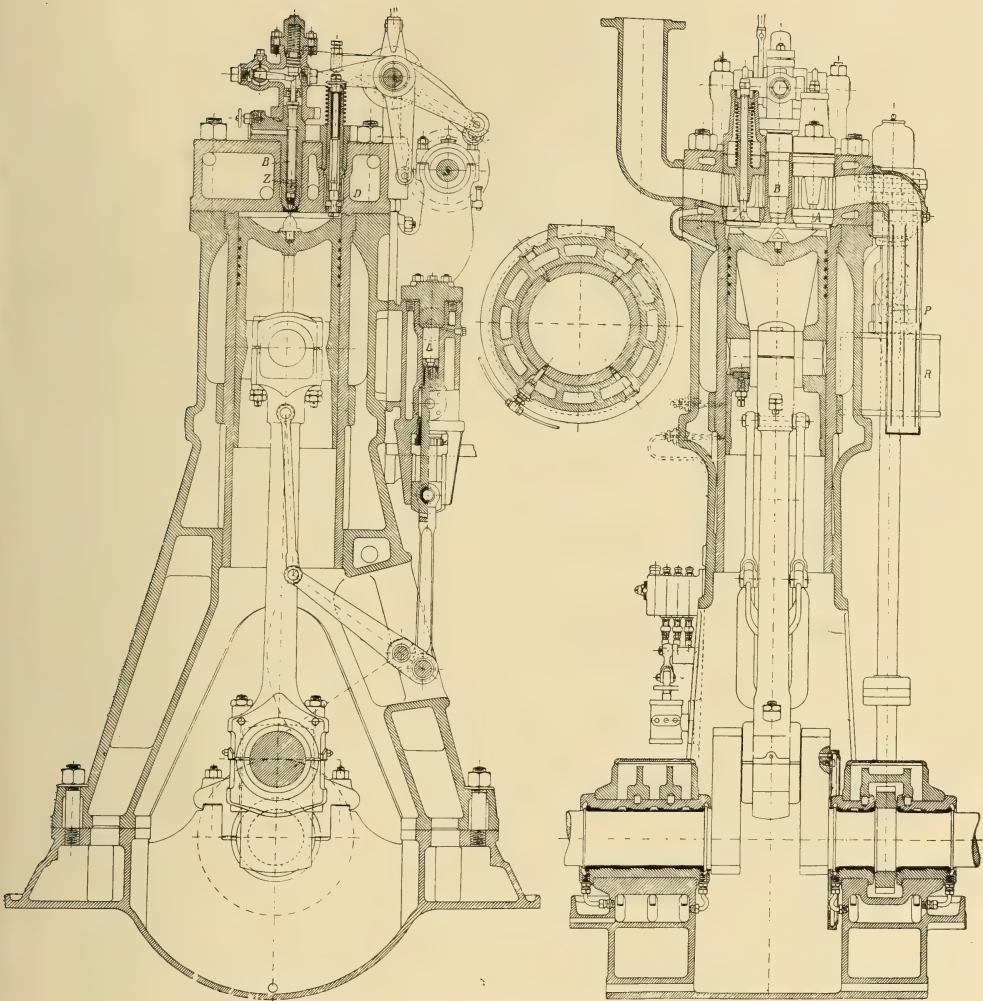


FIG. 2.—STANDARD FOUR-STROKE DIESEL ENGINE.

heads, are situated near the top of the cylinders and driven by a vertical shaft through helical gearing from the crankshaft. This vertical shaft generally carries the governor and at the same time drives the fuel pumps, one to each cylinder; the position of the fuel pump in the section is shown by the letter *P*. In the usual arrangement of the vertical type there are four valves placed in renewable plugs in the cylinder cover, one admitting the air, one for the exhaust, another being a needle valve in the centre which admits the fuel together with the air blast, and a

fourth valve is provided for the supplementary air starting. This latter valve is worked off the same camshaft as the others, but it is thrown out of operation as soon as the engine gets under way and it is so interlocked with the fuel valve that both cannot be in operation at the same time.

The horizontal Diesel engine differs considerably in the details of the valve gear and disposition of the valves, but if represented diagrammatically the sequence of operations is seen to be the same.

An illustration of a modern four-

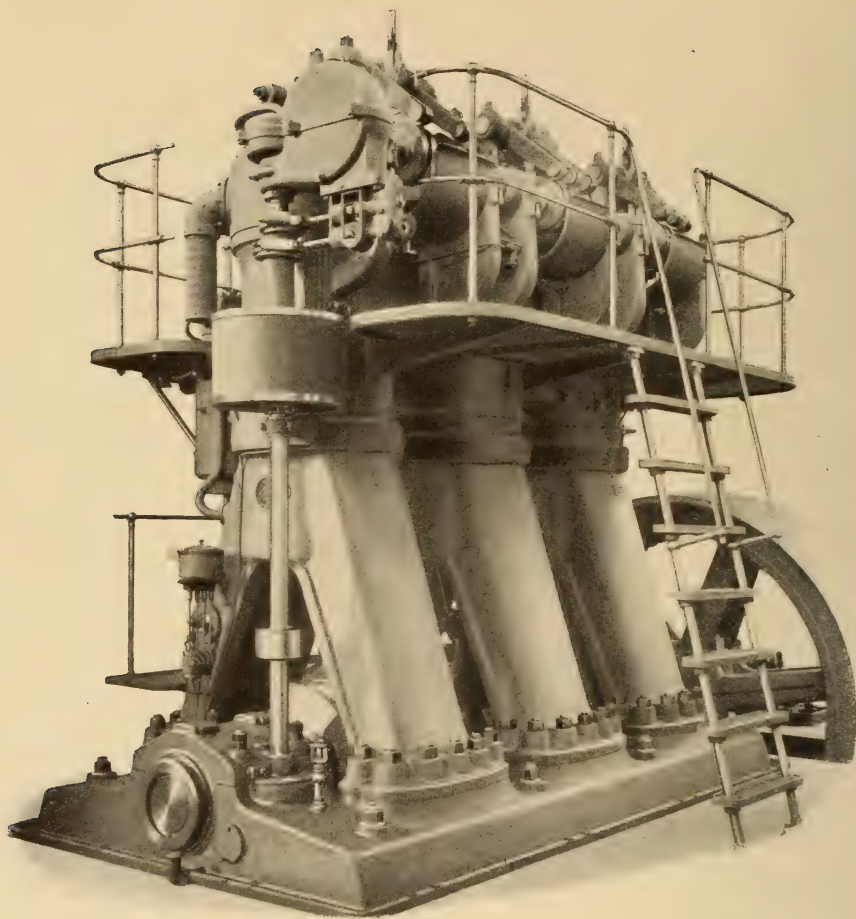


FIG. 3.—FOUR-STROKE DIESEL ENGINE, 300 HORSE-POWER, SULZER BROS., WINTERTHUR, SWITZERLAND.

cycle Diesel motor built by Messrs. Sulzer Bros., of Winterthur, is shown in Fig. 3. This is a three-cylinder engine developing 300 horse-power, and may be taken as representing the design generally followed by most of the builders of four-stroke vertical Diesel engines.

However, within the last few years the Diesel engine has been constructed as a two-cycle engine. In this case the cylinder exhausts at the end of the stroke in the same way as a single acting Körting gas engine, and the accompanying diagram, Fig. 4, shows the cycle of operations:

First stroke: Compression and heating of air (curve 1-2).

Second stroke: (Working stroke)—Combustion (2-2'); expansion (2'-3) expulsion of exhaust gases and introduction of fresh air (3-1).

The peculiar curve at the toe in the Diesel two-stroke card will at once be recognized as being the same shape as in a two-stroke gas engine.

A 750 horse-power two-stroke Sulzer Diesel engine is shown in Fig. 5. This is installed at the electric generating station at Schwyz in Switzerland, and a little attention should be given to this illustration as showing how exceedingly simple the whole installation is. The three welded steel reservoirs for compressed air are seen on the left-hand side of the picture;

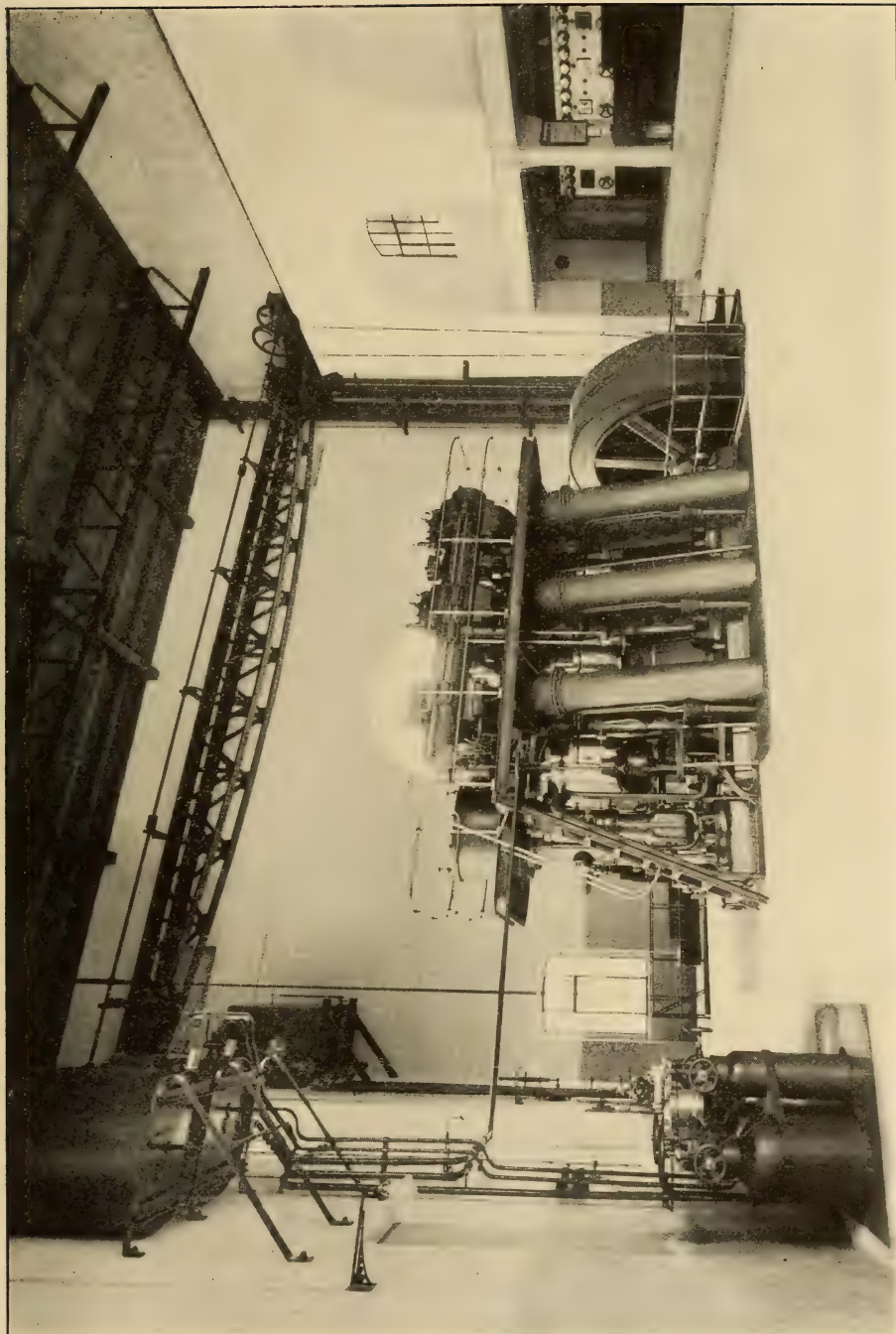


FIG. 5.—DIESEL TWO-CYCLE ENGINE, 750 HORSE-POWER, AT SCHIAVZ, SWITZERLAND, SULZER BROTHERS.

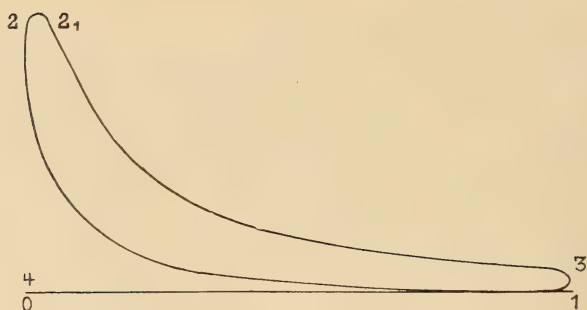


FIG. 4.—DIAGRAM FROM FOUR-STROKE DIESEL ENGINE.

the smaller one of these three is used as the reservoir for the pulverizing blast, while the other two are kept pumped up in readiness for starting. The tanks attached to the wall above supply the oil to the pump on the engine and act as a reservoir for the circulating water. Compared to a steam plant, there are no boilers, economizers or condensers, and as there is no preliminary making of gas, such as is required with gas engines, there are no producers, gasometers or cleaning apparatus re-

quired. The large auxiliary cylinder shown at the governor end of the engine supplies the low-pressure air necessary for scavenging the cylinders where the two-stroke cycle is adopted. The oil pumps, governing arrangement and compressed air starting gear are substantially the same as in the four-stroke engines.

Fig. 6 shows a high speed four-stroke Diesel engine by the same makers, capable of developing 260 horse-power. It will be noticed in this case that the compressor is

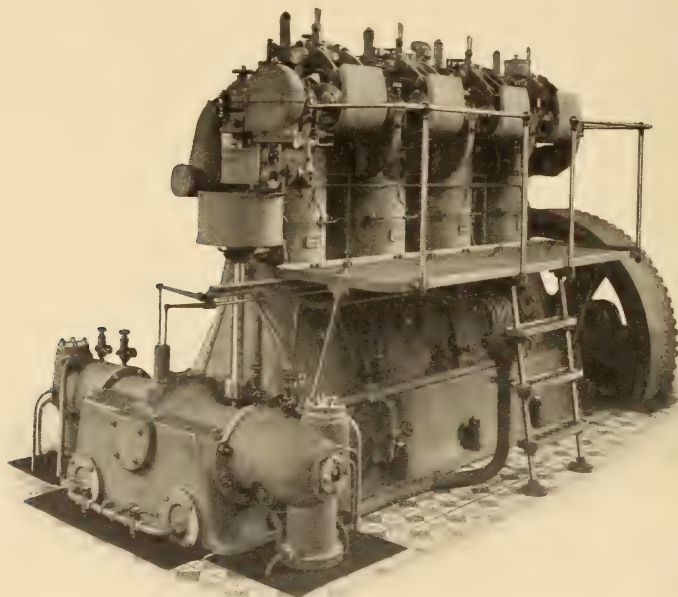


FIG. 6.—HIGH-SPEED FOUR-STROKE DIESEL ENGINE.

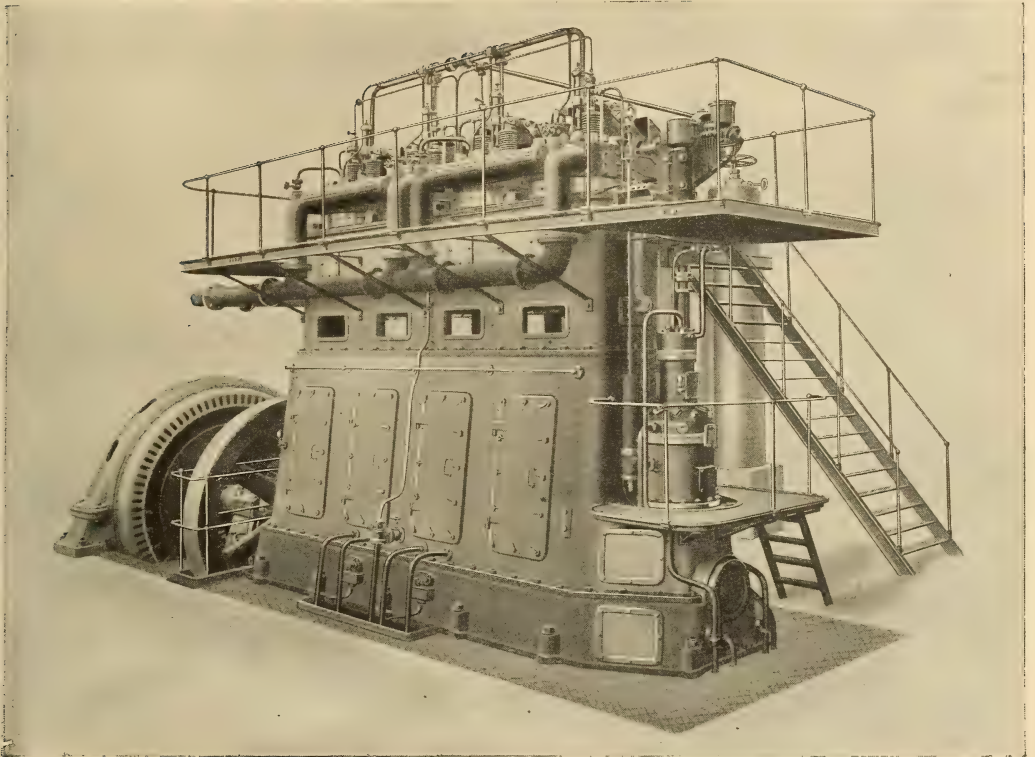


FIG. 7.—DIESEL ENGINE AT BRUSSELS. NEDERLANDSCHE FABRIEK, 600 HORSE-POWER.

placed horizontally at the end of the engine and worked direct from the crankshaft.

Although Messrs. Sulzer Bros. did not show any actual oil engines at the Exhibition, their collection of photographs, drawings and the information they disseminated concerning their Diesel engine enabled anyone to readily understand the developments of this type of engine at the present moment.

Coming now to the 600 horse-power Diesel engine which was shown in motion by the Nederlandsche Fabriek van Werktuigen en Spoorweg-Materieel, of Amsterdam, this was of the following leading dimensions: There were four cylinders of a diameter of 19.6 inches by 25.59 inches stroke, and at 215 revolutions per minute the piston speed was about 925 feet per minute. The

general appearance of the engine can be seen from Fig. 7, reproduced from a photograph, and it externally resembled a high-speed engine of the ordinary enclosed type. The details of construction differed somewhat from the Diesel engine as usually built, since, while the Otto cycle was retained and the cylinders were single-acting, instead of the small ends of the connecting rods being pivoted in ordinary long trunks, short pistons having Ramsbottom rings were used, and these pistons were connected by means of hollow steel piston rods to crossheads working in slipper guides in the lower portion of the frame. This somewhat increased the height of the engine but had certain undoubted conveniences, as the connecting rod was removed from the heat of the cylinder and was easily accessible without re-

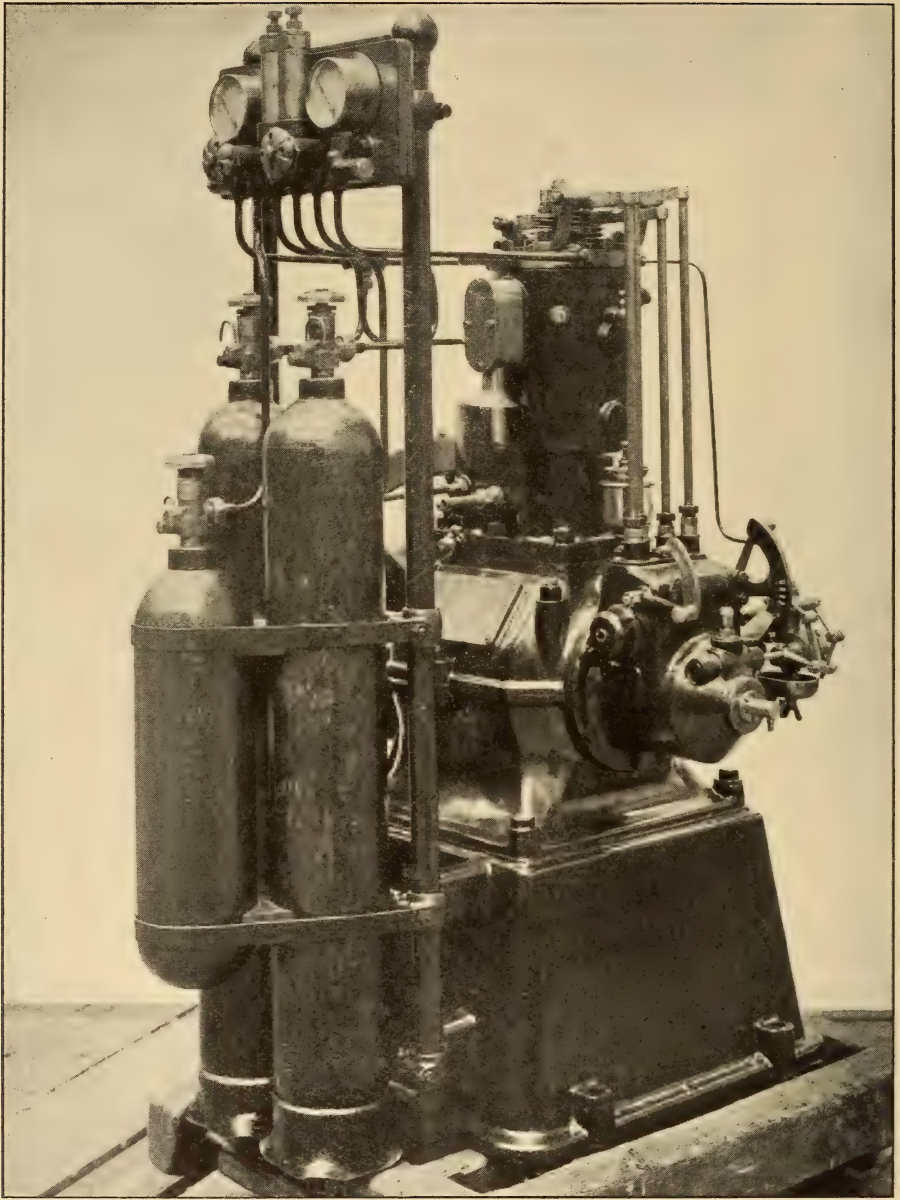


FIG. 8.—ORIGINAL DIESEL MOTOR, SHOWN AT BRUSSELS.

moving the cylinder covers. Access to the interior of the casing was obtained by large doors hinged to the sides, which did not have to be unduly heavy, as all the stresses between the main bearings and the cylinder casting were transmitted by ten steel columns. The casting forming the

four cylinders was formed in one piece fitted with separate loose liners, and while the pistons were water-cooled by trombone pipe connections the hollow piston rods themselves were not cooled. A complete system of forced lubrication was used throughout, and the main bearings

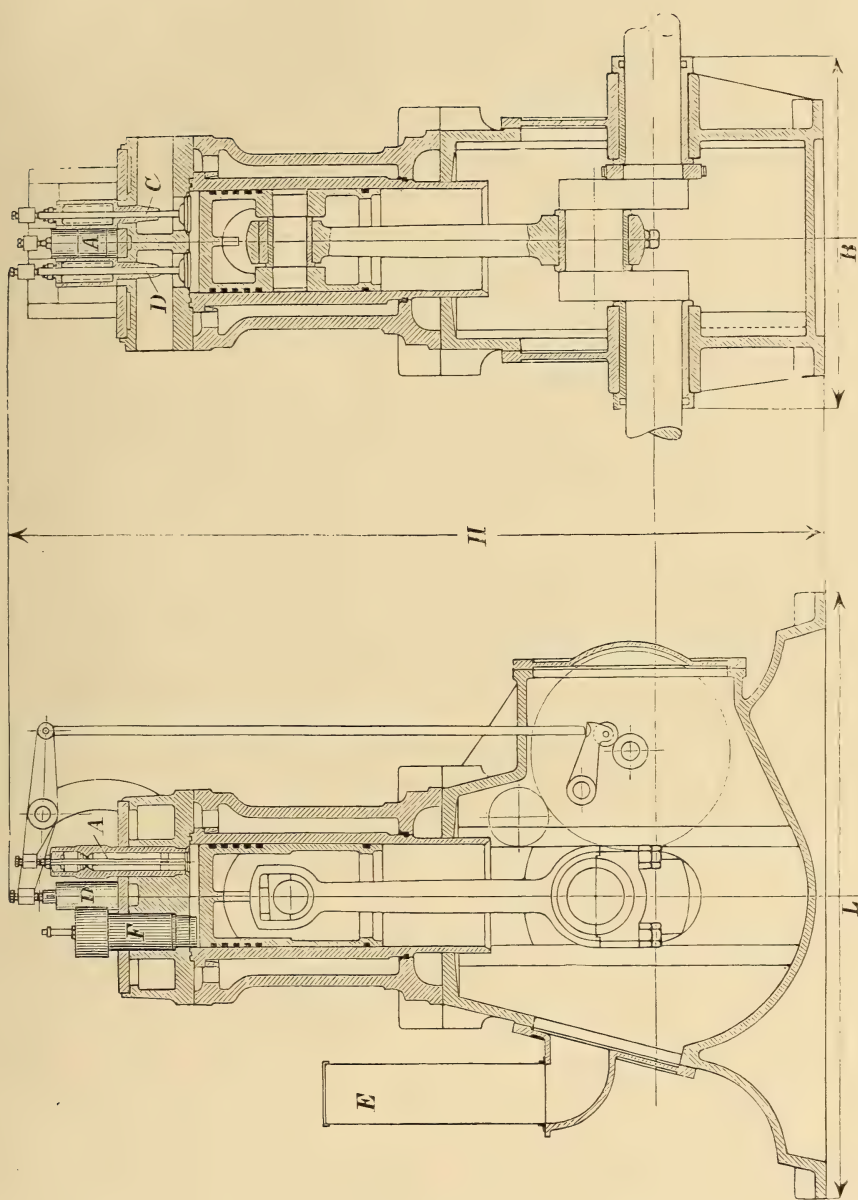


FIG. 10.—SECTIONAL VIEW OF BRONS ENGINE.

were fitted with water-cooling arrangement, having a very neat device for indicating any rise of temperature. The engine drove a two-stage air compressor at one end of the crank-shaft and was coupled at the other end to a continuous-current dynamo giving 745 amperes at

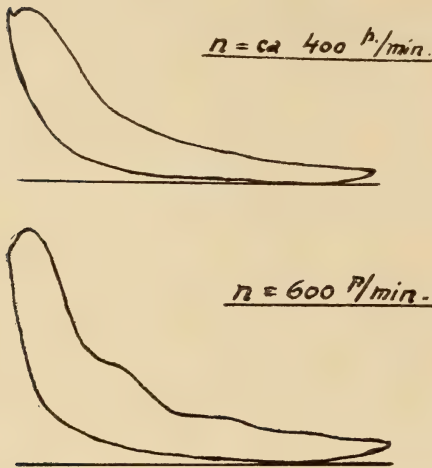


FIG. 9.—DIAGRAMS FROM ORIGINAL DIESEL MOTOR.

470 volts. Owing to the speed of the engine being rather higher than usual the builders decided to use eccentrics, instead of cams, to actuate the valves in the cylinder heads, the eccentrics being coupled to rocking levers which gave the necessary movement to the valve levers proper through hardened steel caps of a suitable profile. This engine formed quite a prominent exhibit in the machinery hall and was the largest internal combustion engine in the exhibition doing any actual work. The makers informed the writer at the time that they had in progress a 500 horse-power reversible Diesel engine for an ocean-going boat or the Nederlandsche Indische Tankstoomboot Company, intended to carry oil in bulk from the company's Borneo wells.

This ship, the *Vulcanus*, has since been completed and put into successful operation. In this engine six cylinders 15¾ inches in diameter by

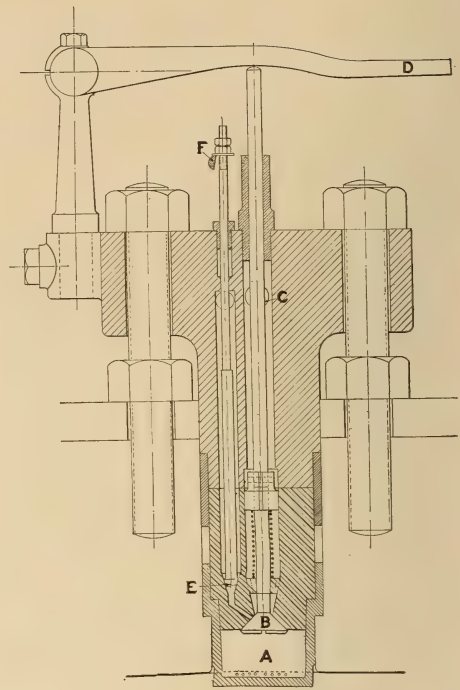


FIG. 11.—SECTIONAL VIEW OF FUEL FEED FOR BRONS ENGINE.

23¾ inch stroke are used and give about 500 horse-power when the engine runs at 880 revolutions per minute. In many respects the design of this engine follows the one shown at Brussels, but a very peculiar form of reversing gear has been adopted. Two cam-shafts are used, but instead of using a vertical shaft with helical gearing to transmit the necessary motion from the main crank-shaft, a couple of eccentrics are keyed on the main shaft and work, by means of long rods, a double-throw crank on an auxiliary shaft above, but it would be impossible without elaborate diagrams to explain the actual method of reversing. Starting is effected by compressed air in the usual way and four large compressed air tanks are provided in the wings of the boat to hold air at a pressure of 300 pounds. These are kept charged up by a two-stage compressor worked by an auxiliary 50 horse-power Diesel engine and when

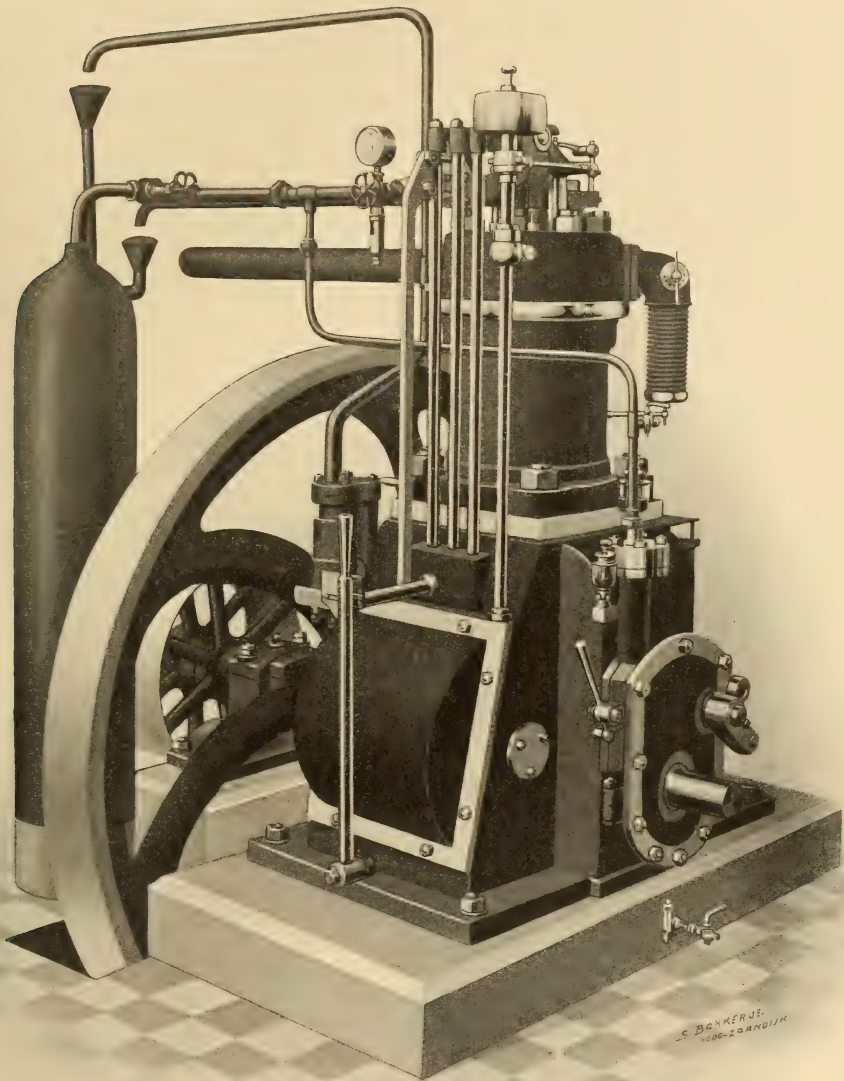


FIG. 12.—THE BRÖNS VERTICAL ENGINE.

required air is taken from these reservoirs to supply four ordinary deck winches as well as a windlass.

The builders evidently seem to regard this order as a prelude to much larger things to come and this feeling seemed to be shared by other builders of large oil engines who exhibited at Brussels.

Messrs. Diesel & Co., of Munich, exhibited in the German machinery hall an engine which they termed the "original Diesel small motor," but what was intended by that term is not made very clear. However, the makers explained very explicitly the object they had in view in constructing these engines, the intention

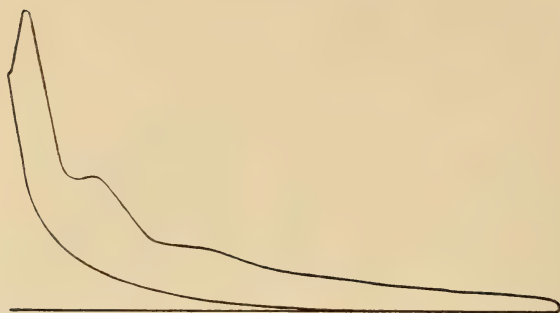


FIG. 13.—DIAGRAM FROM BRONS ENGINE.

being to produce a small quick-running motor which could use crude or cheap residual oils as a substitute for petrol. According to some figures furnished by the makers the difference in the running costs between the two fuels would amount to 3,000 francs in a year of 300 days, assuming that a 5 horse-power engine runs 10 hours a day. These engines are built in several sizes from 1 to 30 horse-power, the number of cylinders varying from one to six, but they all run at the same speed of 600 revolutions per minute. An exterior view of a small 5 horse-power size is given in Fig. 8. Apparently the engine itself appears to

be somewhat overshadowed by the compressed air bottles and gauges seen in front, but where the engine is used for driving dynamos and pumps and the bedplate has to be lengthened to receive these the bottles are stowed away in the base, making a very compact arrangement. The engines work on the four-stroke cycle and operate just in the same way as the larger Diesel engines already described.

In the single-cylinder arrangement illustrated the two-stage air compressor is placed vertically alongside the working cylinder and is surrounded by the same water jacket. The piston of this compressor is

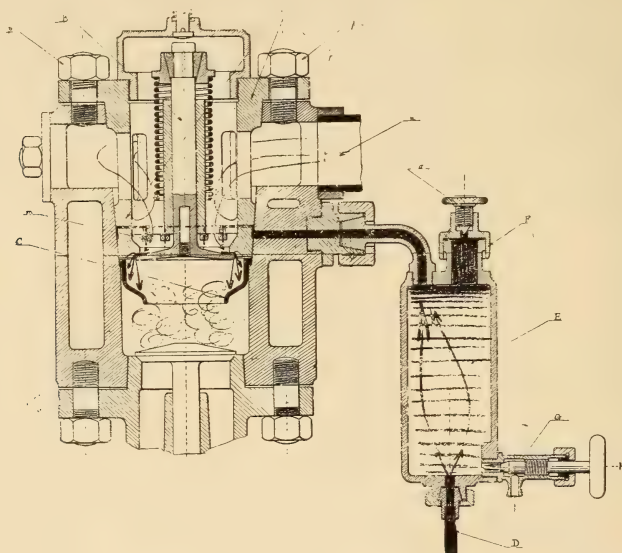


FIG. 14.—SECTION OF KROMHOUT MOTOR.

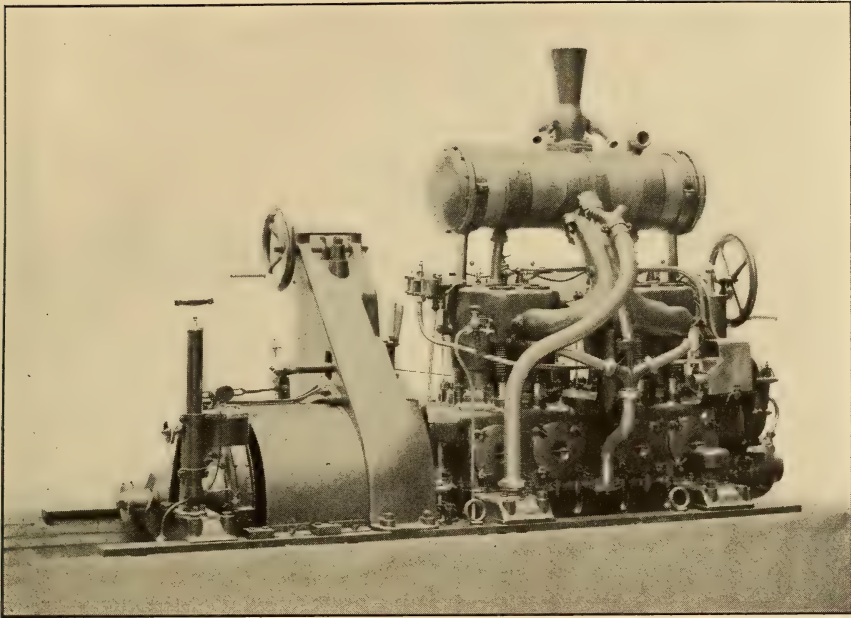


FIG. 15.—DAIMLER REVERSIBLE MARINE MOTOR.

worked from a small crank formed on the web of the main crank, and the crankshaft itself revolves on ball-bearings on both sides. The valves are, as usual, placed in the cylinder cover and are actuated by levers and vertical rods worked by cams fixed on a shaft at right angles to the main shaft and driven therefrom by skew gearing enclosed in the crank-case. An automatic arrangement is applied so that when the starting bottles are pumped full the compressor is automatically cut off from them and then delivers directly into the cylinder. Two indicator diagrams taken from this engine are shown in Fig. 9. Some very careful tests of an engine of this sort were recently carried out by Prof. F. Romberg of Charlottenberg, and apparently a high efficiency was obtained, but the writer was not able to identify the calorific value of the Galacian raw oil used. It is usual to assume the usual grades of crude oil to have a value of about 18,000 British thermal units per pound, and responsible makers will give guarantees with a fuel of this quality of:

0.463 pound at normal load per brake horse-power hour.

0.485 pound at $\frac{3}{4}$ load per brake horse-power hour.

0.562 pound at $\frac{1}{2}$ load per brake horse-power hour.

In the large Dutch Diesel engine shown at Brussels the consumptions were as follows:

Pounds per brake horse-power, full load, 0.37; $\frac{3}{4}$ load, 0.429; $\frac{1}{2}$ load, 0.495; $\frac{1}{4}$ load, 0.77.

Photographs of various-sized Diesel engines were shown by Franco Tosi Milan, and the Augsburg & Nurnberg Works (M. A. N.) Co. also showed a series of photographs of marine reversible engines for submarine purposes.

Two vertical Brons motors were shown in the Dutch section of the Machinery Hall by the Appingedammer Bronsmotorenfabriek, Appingedam (Holland), of which firm the original inventor, Mr. J. Brons, is a director. One of these engines was of 12 horse-power and intended for driving a dynamo and the other was of 10 horse-power for marine work. This engine ran at 560 revolutions

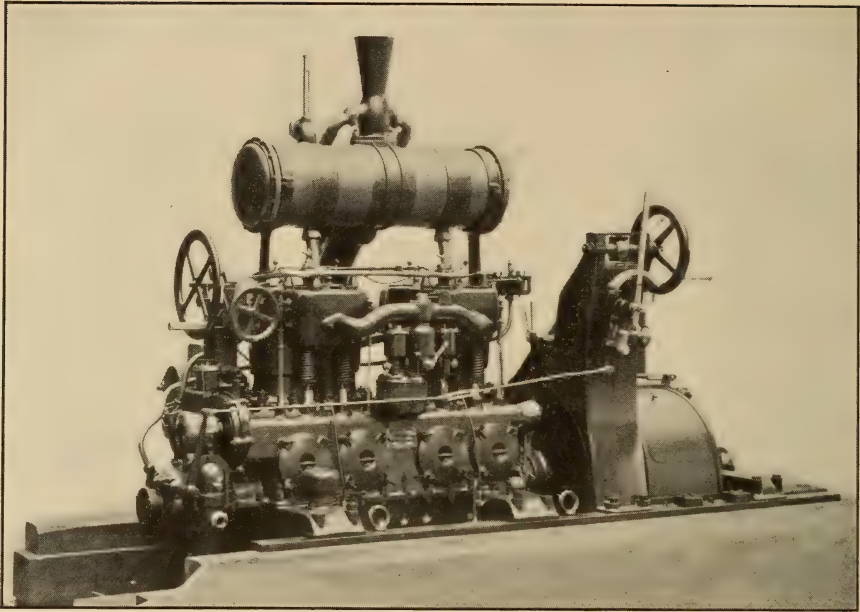


FIG. 16.—REVERSIBLE MARINE MOTOR, DAIMLER MOTOREN GESELLSCHAFT.

per minute, the cylinder diameter being 6.29 inches, with a stroke of also 6.29 inches. Both these exhibits attracted a good deal of attention as representing a type which has now come to be classed as "semi-Diesel engines." The Brons system differs from the Diesel inasmuch that no spraying blast is used and the fuel oil enters the cylinder during the suction stroke along with the air, but it resembles the Diesel engine in that the heat necessary for ignition is obtained during the compression stroke and that the bulk of the fuel charge is only vaporised during the beginning of the working stroke, and the manner in which this is brought about is exceedingly simple and ingenious. The engine works on a four-stroke cycle, and, as will be seen from the sectional views, Fig. 10 has the usual arrangement of air inlet and exhaust valves worked from a half-speed shaft in the base; but the point of novelty is the method of admitting the oil and delaying its complete combustion. The arrangement for effecting this can be best seen from Fig. 11. The oil is supplied to the admis-

sion valve under a slight head usually obtained from a tank above, and during the suction stroke it is allowed to enter the spraying chamber *A* when the valve *B* opens, mixing at the same time with air entering through the hole *C*. This admission valve *B* is depressed by the lever *D*, operated from the lever of the main air inlet valve, and opens a little later and closes a little sooner than the latter. The spray box *A*, which receives the oil as it enters, has a series of small holes or ports in it connecting with the interior of the working cylinder, and, although the bulk of the charge goes into the spray box in liquid form, a sufficient amount of it is at once vaporised to form a weak mixture in the cylinder, and by the time the end of the compression stroke is reached the temperature has so far risen that this weak mixture automatically fires. This explosion, though comparatively feeble, is communicated to the charge still remaining in the spray box and drives it out into the cylinder partly as a rich mixture and partly in a liquid form, which is at once vaporised and com-

bines with the excess of air in the cylinder. Of course, the more oil that has been admitted to the spray box during the suction stroke the more combustible there is to be burned, and, therefore, the pressure is more or less sustained until it is all gone and the expansion period commences. The amount of oil admitted is regulated by the conical valve *E*, controlled by a half-round cam *F* connected to the governor. At the end of the expansion stroke the exhaust valve opens and the products of combustion are expelled in the usual way during the next stroke. In the small engines up to 10 horsepower starting is effected by turning the flywheel round until the heat necessary to ignite the charge is obtained from the compression. In the larger engines above 10 horsepower compressed air starting is used, and the valves are so arranged that the engine works as a two-stroke engine during this period. Thus there are four valves required in the cylinder head, one for the admission of air, one for the exhaust, one to admit the air and draw in the oil charge, and the compressed air starting valve, which is thrown out of operation when the engine is running. The exterior of one of these Brons engines is shown in Fig. 12. The writer is not aware whether any official tests were made during the Exhibition as to the actual consumption of oil on these engines, but a report was made on a 12 brake-horsepower one in February, 1909, by Prof. Dijxhorn, and an indicator diagram accompanying this report is shown in Fig. 13. At 12.2 brake-horsepower the engine ran at 298 revolutions per minute, and when an overload up to 14.8 horsepower was put on the engine was regulated to run at 310 revolutions without any trouble, and when the load was thrown off as much as possible the revolutions only rose to 316, being an increase of 1.94 per cent.—a very good result, considering the extremely simple form of regulation. The oil

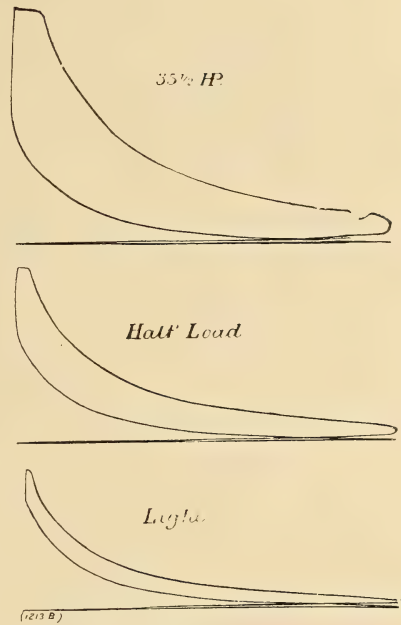


FIG. 17.—DIAGRAMS FROM BLACKSTONE ENGINE.

used in these tests was supplied by the Dortsche Petroleum Company, and the consumption was 0.487 pounds per brake-horsepower-hour. It was stated that any of the oils that could be used for the Diesel engine were equally suitable for the Brons motor, and apparently the oil was burnt to complete combustion as far as could be judged from the absence of deposit and from the appearance of the exhaust. There were several ingenious constructive features about the engine—for instance, in the way of removable packings for varying the compression between the top of the trunk and the cylinder head. In the larger engines the compressed air pump for charging up the starting reservoir is worked off the engine itself, and an unloading device is fitted so that when the pressure in the reservoir reaches 120 pounds the compressor ceases to operate.

The patent rights for Germany, Russia and Belgium have been acquired by the Deutz Gasmotoren Fabrik, of Cologne, and they exhibited in the German section a

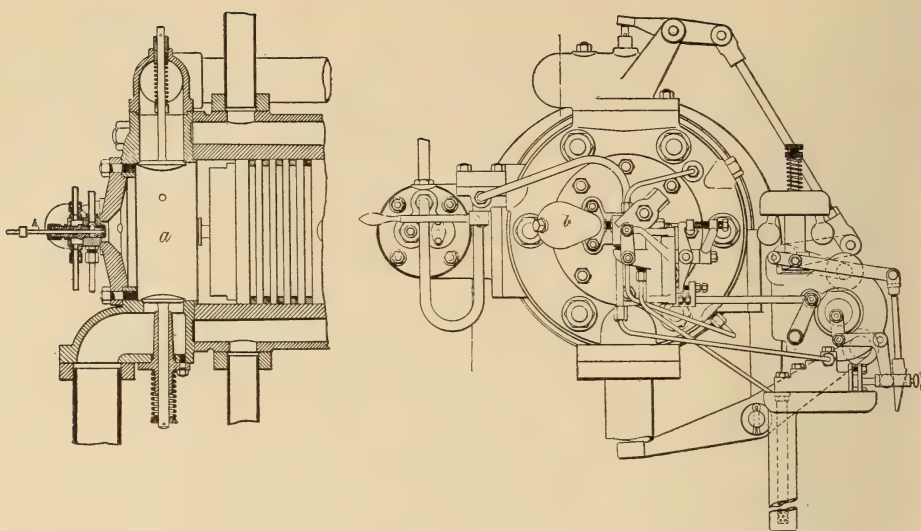


FIG. 19.—DETAILS OF BLACKSTONE ENGINE.

Brons engine applied for marine purposes. The engine closely resembles the original Dutch model, and is made in standard sizes from 8 to 32 horsepower for fishing boats and the like. A vertical lever placed in proximity to the flywheel is for reversing the angular position of the propeller blades and illustrates the simplest and most elementary form of arrangement for

reversing the motion of a boat with an engine running constantly in one direction.

A considerable difference of opinion exists amongst makers as to what are the limitations of this system of reversing, many makers preferring to use, even in their moderate-sized engines, the train of wheels and friction clutch described on the Crossley engine, the screw blades being in this case fixed and the direction of the propeller shaft reversed relatively to that of the engine. In the larger engines the motion of the engine itself is reversed, together with that of the propeller. An example of this kind was seen on the Blackstone marine engine.

Several schemes have lately been put forward for using oil engines in combination with electric generators and driving the screw shafts themselves by electric motors, and Messrs. Mirrlees, Bickerton & Day have proposed an arrangement in which electrical transmission is employed, but which only comes into operation at reduced speeds and when going astern; but practical experience at sea will alone tell how far the results justify the extra cost and complication.

The Kromhout motor, built by D.

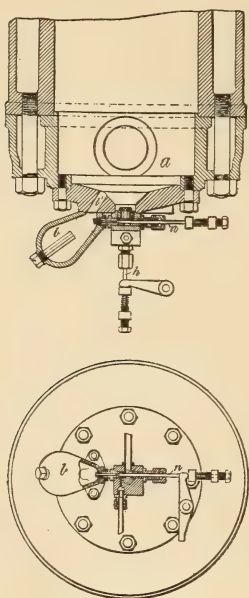


FIG. 20.—DETAILS OF BLACKSTONE ENGINE.

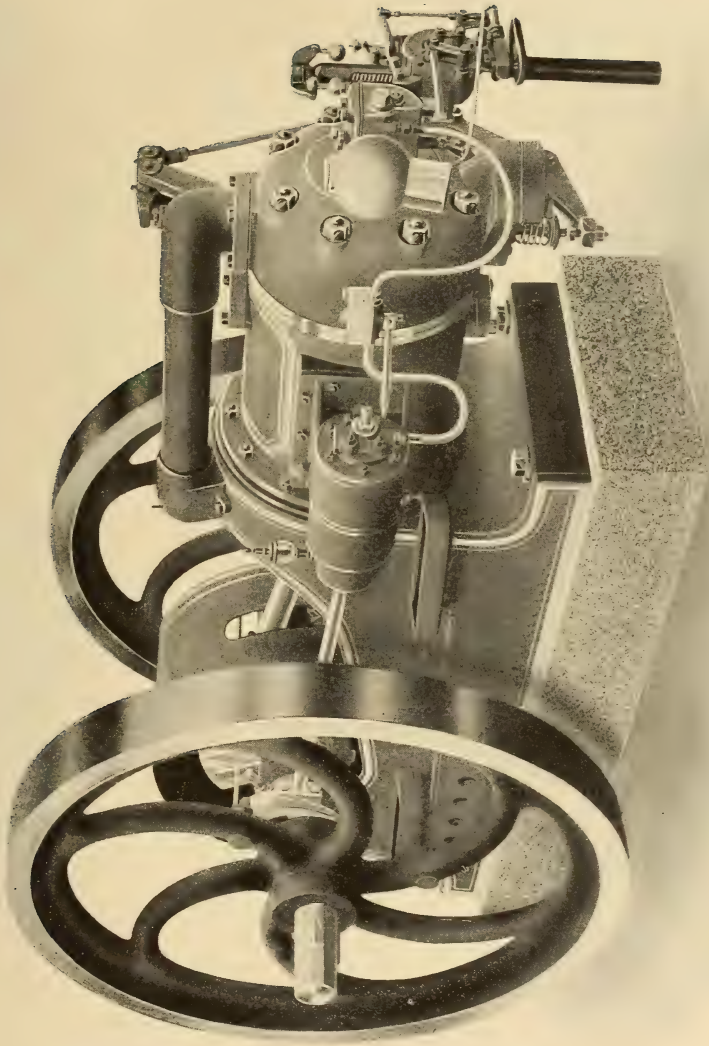


FIG. 18.—THE BLACKSTONE OIL ENGINE.

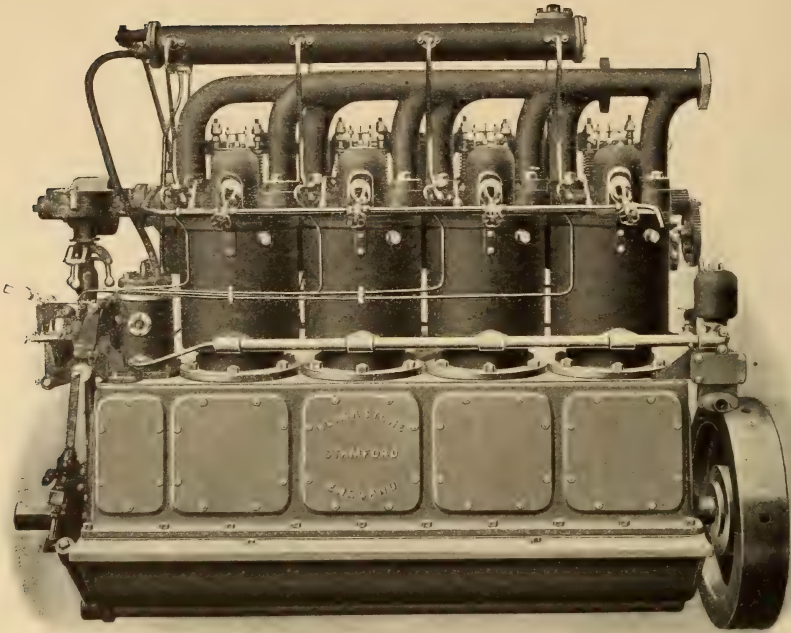


FIG. 21.—REVERSIBLE BLACKSTONE MARINE ENGINE.

Goedkoop, Jr., of Amsterdam, was exhibited in the Dutch section, and had some quite original features about it. This engine has been described in some detail in a brochure entitled "Les Moteurs Marins à Pétrole Lampant," by Marcel Plessix, but can only briefly be referred to here. The engine works on the four-stroke cycle, and the chief peculiarity of it is the arrangement of the admission valve and vaporiser, which is shown in section in Fig. 14. The oil fuel is fed by means of a pump into an annular groove in the valve seating *A* and passes through six small spraying nozzles just above the admission valve *B*, which opens into a vaporiser *C* in the form of a truncated cone. After the engine is started the vaporiser is kept hot by the successive explosions, and, as it is placed just above the exhaust valve, its position assists it in this respect. Owing to the peculiar conical shape of the vaporiser any oil which is not instantly converted into mixture on

the opening of the valve *B* strikes on the hot sides of the vaporiser and the residue of the oil which cannot be gasified adheres to the body of it in the form of coke or tarry matter and does not enter the working part of the cylinder. As ready access can be obtained to the vaporiser by simply taking out the valve seating above what does deposit, it can be easily cleaned out when this is judged to be necessary. The small reservoir *E* shown on the right-hand side of the figure is merely an enlargement of the oil fuel supply pipe, and is intended to hold a sufficient charge of petrol to start the engine up, as otherwise the vaporiser would have to be independently heated. The ignition gear employed is low-tension Simms-Bosch, the sparking contacts being placed in the centre of the cylinder head. These engines are built in standard sizes up to 30 horsepower with one cylinder and to 76 horsepower with two cylinders, the smaller sizes running at 360 revolu-

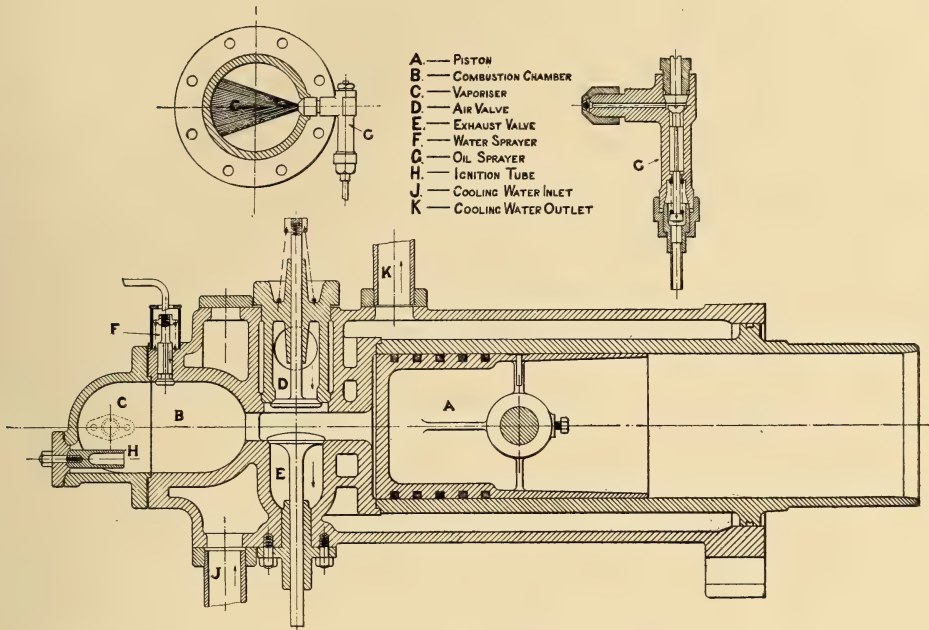


FIG. 22.—SEMI-DIESEL ENGINE, CROSSLEY BROTHERS.

tions per minute and the larger sizes 265. This motor seems to be extensively used abroad, both for pleasure purposes and as an auxiliary power for sailing ships. Some comparatively large vessels are equipped with twin screws driven in this way.

Mention should also be made of the engines exhibited by the Maschinenfabrik Drakenburgh, formerly D. W. Van Rennes, of Utrecht. These were certainly of a very robust construction, and the writer regrets it was impossible to obtain any detailed information concerning them.

It is, perhaps, hardly realized that the business of building small oil engines for fishing boats and auxiliary purposes has developed to an enormous extent during the last few years, the Scandinavian makers alone having sent out large numbers for use in the Eastern waters.

The Daimler-Motoren Gesellschaft, of Berlin-Marienfelde, showed in the German section a beautifully finished reversible marine motor which, at 700 revolutions per minute, developed about 115 horse-power when

using petrol or alcohol, and about 92 horse-power when using paraffin. This motor, which is illustrated in Figs. 15 and 16, had four cylinders, each $7 \frac{9}{32}$ inches in diameter, with a stroke of $9 \frac{15}{32}$ inches. The valves are symmetrically arranged, the inlet valves being on one side of the engine and the exhaust valves on the other. Under all conditions petrol is used to start the engine, but the carburetter is so arranged that it can be made to run on alcohol or paraffin afterwards. A wide range of speed variation, from 700 revolutions normal to 250 minimum, can be obtained by simply varying the mixture, and reversing is effected by an epicyclic train of gearing and handwheel controlled by the handwheel shown on the right-hand side of Fig. 16. The ignition is caused by a Bosch magneto apparatus driven off the valve shaft, and the engine is started by pumping mixture into the cylinders by a hand pump and then sharply turning the ignition gear. A separate oil pump serves for forced lubrication of the main connecting-rod

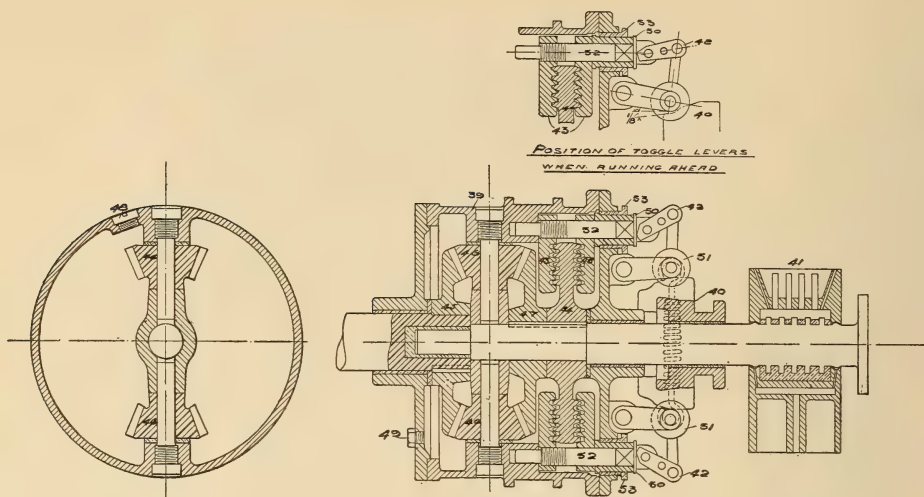


FIG. 23.—CROSSLEY REVERSING GEAR.

bearings, and another pump supplies the cooling water to the exterior of the cylinders, exhaust pipes and exhaust chamber seen above the engine. The crank chamber was provided with large inspection doors, and generally the engine was very well arranged for easy examination of the interior. A considerable number of these engines have been fitted in racing yachts; but, at the same time, they are built so as to comply with the regulations of the German Imperial Marine.

Two very interesting crude oil engines were shown in the English section of the Machinery Hall by Messrs. Blackstone & Co., Ltd., of Stamford. One of these was a 25 horse-power horizontal engine and the other an 80 horse-power vertical, four-cylinder marine reversing engine. Although both these designs had been previously seen on the English show grounds, the peculiarities of their construction attracted a good deal of notice at Brussels. This design embodies some of the features of the Diesel engine, and the indicator diagrams, Fig. 17, taken at varying loads, show that the pressure line remains parallel to the atmospheric line, and is longer or shorter according to the load at the moment, as is the case in a Diesel diagram. The Black-

stone engine works on the four-stroke cycle; but, while in a Diesel engine the air in the cylinder is raised by compression alone to a sufficiently high temperature to ignite the injected fuel, in the Blackstone design the free air taken in during the suction stroke is only raised to a pressure of 150 pounds at the end of the compression stroke, and the heat necessary to ensure certainty of ignition is derived from a hot bulb or separate ignition chamber. At every revolution of the half-speed camshaft a certain definite amount of oil, depending upon the position of the governor, is forced into a peculiar form of spray box, and at the proper time this charge of oil is driven by a blast of air partly into the main combustion chamber at the back of the cylinder and partly into the ignition bulb. Air at about 400 pounds pressure is used to supply this blast, and is taken from a small reservoir kept charged by a separate air pump worked by an eccentric on the main crankshaft.

This can be clearly seen from the illustration, Fig. 20, which also shows the relative positions of the hot bulb, spray box and oil pump. The essential features of the spray and igniting devices can be best understood from a slightly modified reproduc-

tion, Fig. 19, of the patent drawing of Messrs. Blackstone & Carter's specification of 1908, showing, respectively, a longitudinal section of the combustion chamber, with air inlet and exhaust valves, and end view of the cylinder, with oil pump and valve gearing, details of the hot bulb and horizontal section with hot bulb and fuel valves. The same lettering applies in all the views: *a* is the main combustion chamber of the engine, having the air inlet valve above and the exhaust valve below; the hot bulb is indicated by *b*, and is attached to one side of the spray box, which is a rectangular steel block bored out to receive two needle valves, the one marked *h* being axial with the centre of the cylinder and controlling the admission of the sprayed oil into the combustion chamber, while the other needle valve *n* is placed a little above this and at right angles to it and controls the spray of oil entering the hot bulb *b*, which is fitted with a stalk of refractory material to retain the heat between the explosions. The sudden rise of pressure produced by the injection of the oil into the bulb *b* drives out a flame through the inclined port *l* communicating with the combustion chamber, and this

flame intersects with and ignites the main spray coming from the valve *h*. The air pressure to cause these sprays is produced by the auxiliary air pump on the side of the engine already referred to.

The oil passages in the spray box are so proportioned that, whether the engine is running light or loaded, the same amount of oil is always injected into the bulb *b*, which is thus kept at the constant necessary heat. When the engine is running light the governor only permits the pump to deliver enough oil to supply the charge for the bulb; but as the load increases and the pump is caused to deliver more oil, a greater amount is sprayed into the combustion chamber *a*, thus keeping the pressure constant behind the receding piston until the needle valve closes and the expansion curve begins; and, in consequence, a high mean effective pressure can be obtained without an excessive maximum pressure, the working stresses thus being considerably reduced. As a matter of fact, if the pressure at the end of the compression stroke is 150 pounds the maximum obtained with the explosion is about 320 pounds, and this is not increased by a further supply of oil into the com-

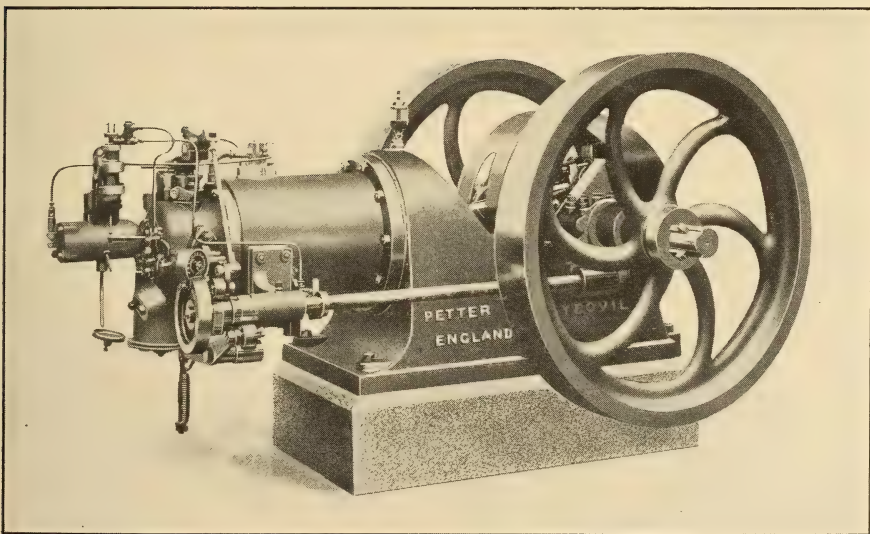


FIG. 24.—THE CAMPBELL CRUDE OIL ENGINE.

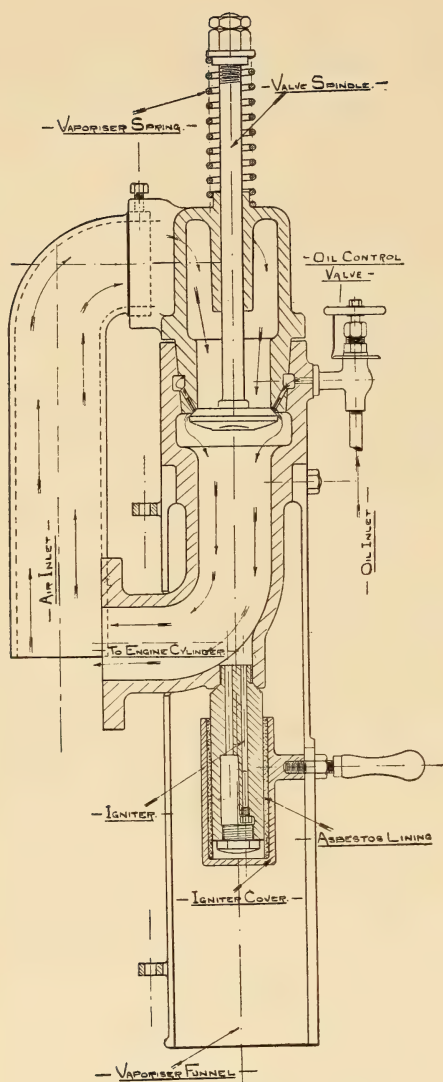


FIG. 25.—THE CAMPBELL VAPORISER

bustion chamber, although this, of course, determines the mean effective pressure. The hot bulb is heated up on starting in the usual way by the temporary application of an external lamp, and when this is hot enough the engine is started from a compressed air reservoir by means of a simple form of control valve. Apparently the engine could burn any class of oil that could be used in Diesel engines; and at the Gloucester trials held in 1909 only 0.5 of a

pound of crude Texas oil was found necessary to produce a brake-horsepower-hour, and if the cost of this was taken at $2\frac{1}{2}$ d. per gallon the fuel costs come out 0.181 of a penny. The vertical marine engine exhibited at Brussels embodied the same system of spray box and auxiliary heating bulb, and, while the four-stroke cycle was retained, the engine was fitted with a most ingenious system of reversing gear. In this engine the hot bulbs were heated up in the first instance by external lamps in the same way as in the horizontal engine; but, when once running, the engine was reversed and manipulated by compressed air obtained from the same reservoir which supplied the spray blast. The operation of reversing is considerably simplified by making the exhaust and air inlet valves function in either capacity; thus when the engine is reversed the valve that has been acting as the air inlet valve becomes the exhaust valve and the exhaust valve becomes the air valve. This is brought about by shifting the camshaft endways and causing two different cams to operate the same bowl on the end of the valve lever. The actual reversal of motion is effected by compressed air taken from the reservoir that feeds the spray boxes. This supply of air passes through a control box containing a two-way valve, and when the engine is running normally in either direction it goes straight to the spray boxes, but when it is desired to reverse the engine the valve is moved firstly so that the air supply is cut off from the spray boxes and the cylinders altogether. Then the camshaft is moved axially, so that the exhaust and air valve cams shift their respective positions ready to operate the valves in the proper sequence as soon as the fuel is again admitted. The spindle of the control valve is geared with an eccentric shaft carrying the levers operating the air starting valves. When running normally the bowls on these starting valve levers are clear of the cam-

shaft and the valves remain closed; but as the control valve is turned to direct the air from the spray to the starting valves simultaneously the eccentric shaft brings the starting valve levers under the influence of their cams, and the air is supplied to one or other of the cylinders during the up stroke, thus reversing the direction of rotation. When the engine is got under way again the control valve is put back to spraying position and the starting valves go out of operation. The oil pumps

ing purposes, and, although the description of the reversing operations may seem somewhat involved, in practice the method of manipulation is quite simple.

The gas engines shown by Messrs. Crossley Bros., Ltd., of Manchester, have been referred to in a previous chapter, but they also showed on their stand several engines using petrol and some of the heavier oils. Amongst these was a 47 horse-power engine which they termed a semi-Diesel, and which was intended to

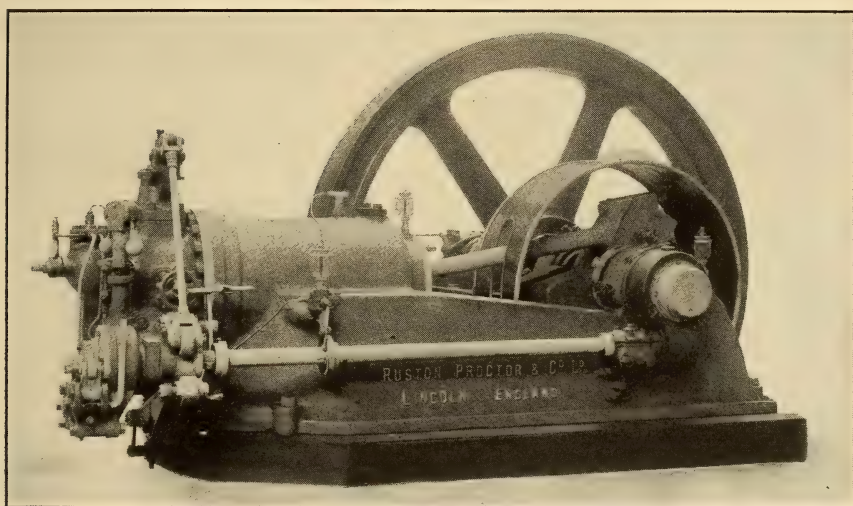


FIG. 26.—RUSTON & PROCTOR 40 HORSE-POWER OIL ENGINE.

are actuated by gearing off the vertical shaft and are controlled by a series of wedges in the same way as in the horizontal engine. Prior to reversing the engine the oil supply is cut off from all the pumps by means of an unloading device on the governor, and communication is made again as soon as reversing has been effected. A general view of the engine exhibited at Brussels is shown in Fig. 21. The small air compressor for supplying the reservoir can be seen at the left-hand side of the bed near the governor, the reservoir itself being placed above the interchangeable air and exhaust pipes.

Already quite a number of these engines have been supplied for fish-

work with either refined or crude oil. Some sectional views of this are given in Fig. 22, which, to a large extent, explains itself. The oil fuel is injected at the moment that the compression in the cylinder is at the highest point, and the actual ignition is effected by the hot tube *h*. The vaporiser is of the lampless type, that is to say, the lamp is removed from it after the engine is once started. The valve *f* controls the water spray, which has been found beneficial in this type of engine, and the oil-spraying device is shown by *g*. Messrs. Crossley also showed a 20 horse-power marine engine of the design that they brought out to work on the Dutch canals.

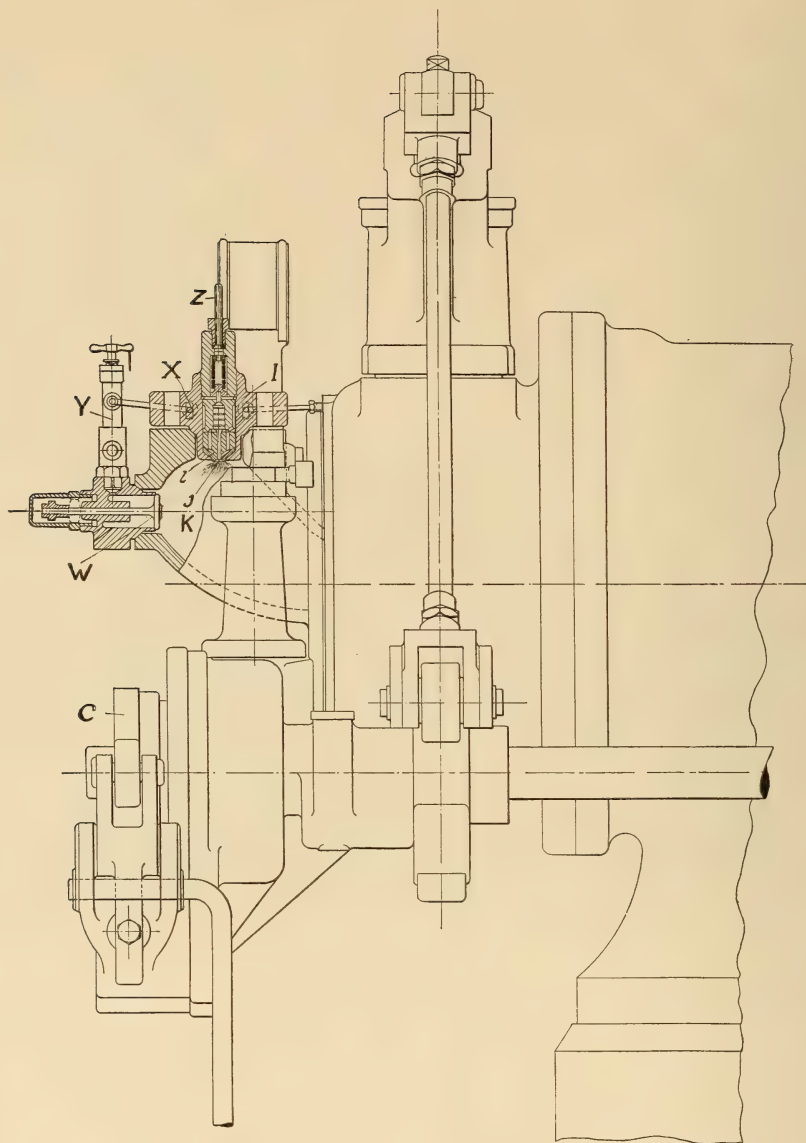


FIG. 27.—OIL FEED FOR RUSTON & PROCTOR ENGINE.

The engine itself has several novel features and was fitted with a very substantial reversing gear, which the writer has illustrated in Fig. 23, as it is a good illustration of this type of epicyclic control, and a proper comprehension of this particular mechanism will enable all the reversing gears of this type to be easily understood. The whole of the moving mechanism is enclosed in a gear case,

39, which is controlled by a powerful friction band, which can be tightened or loosened on the exterior of the gearcase by the movement of a lever on deck. This lever also works a sliding sleeve, 40, having an inclined profile acting on toggle joints, 42, which caused the grooved friction plates, 43, in the gearcase to grip or recede from the grooved disc, 44, keyed to the propeller shaft.

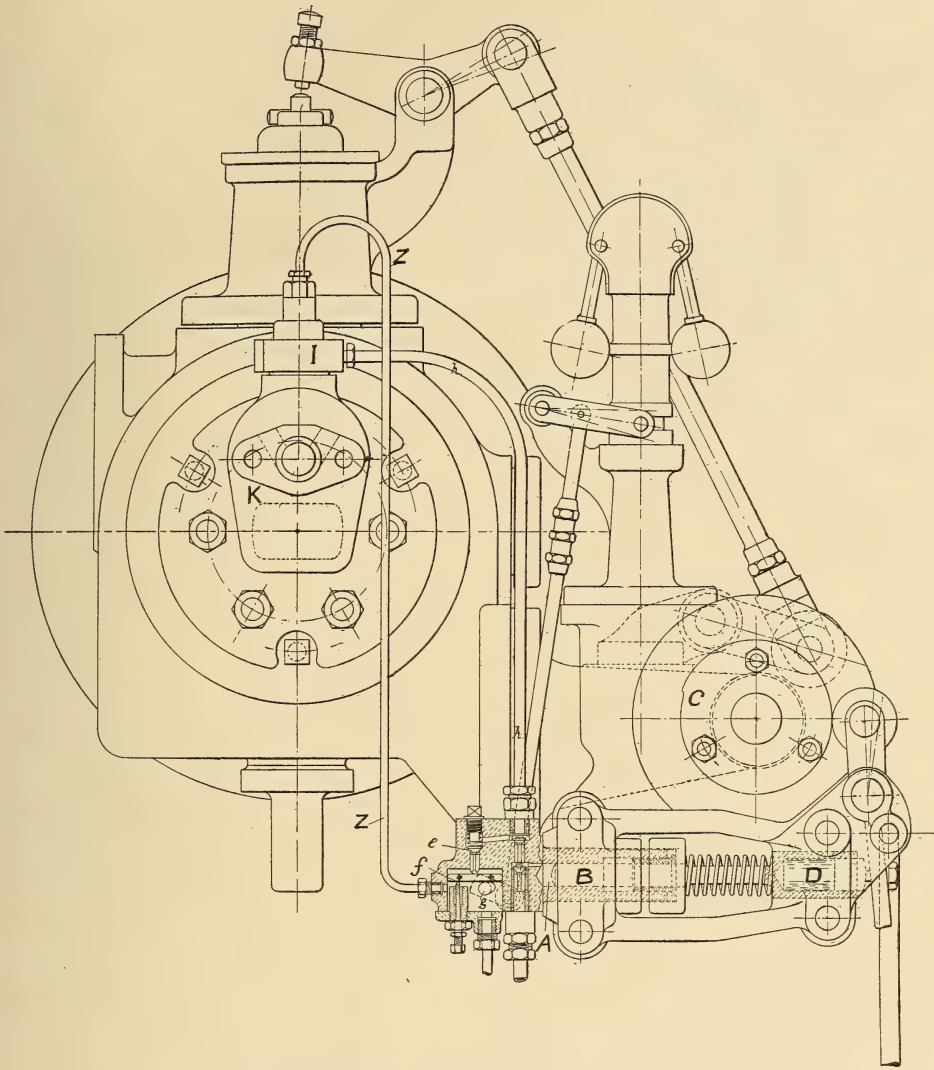


FIG. 28.—VALVE GEAR OF RUSTON & PROCTOR ENGINE.

When the sleeve is in the extreme outer position powerful springs pull the toggles together and the gear box is locked to the propeller shaft through the friction plates, 43, pressing on the disc, 44; the whole system of wheels then revolves together and the propeller shaft becomes practically a continuation of the crankshaft, the brake band not coming into operation. This is the position for going ahead. For reversing the sleeve is moved inwards, forcing the

toggle joints outwards and releasing the friction plates from the discs, 44. The continued movement of the control lever then causes the friction band to grip and hold stationary the exterior of the gearcase, and, in consequence, the bevel wheel, 45, on the end of the crankshaft drives the bevel wheel, 47, on the propeller shaft at the same speed, but in the reverse direction, through the bevel pinions, 46. When the control lever is in the intermediate position the gear-

case is neither clutched to the propeller shaft nor held to the friction band and, if the propeller shaft is prevented from turning, the gearcase simply revolves round it at half the speed of the crankshaft in a similar way to a free-wheel bicycle. This combination made a neat arrangement, and was quite easy of control. Magneto ignition was used on the engine, which was designed to give its normal power at a speed of 300 revolutions per minute.

Messrs. Crossley also showed several other smaller engines, some of which could be either worked with oil or by gas.

The Campbell Gas Engine Company exhibited an oil engine of about 18 horse-power, maximum, which is illustrated in Fig. 25. This was of the lampless type in which the vaporiser only required external heat supplied to it for a few minutes when starting up. This oil engine follows the general design of the Campbell gas engine, and these are built up to 70 horse-power with one cylinder, and from 80 to 140 horse-power with two cylinders. The vaporiser and ignition arrangements are of extremely simple nature and the exhaust valve is the only valve connected with the cylinder that is mechanically moved. No separate pump is required to supply the fuel oil, as this is drawn through into the vaporiser and mixes with the air during the suction stroke. A sectional view of the air inlet valve, oil ducts, vaporiser and ignition device is shown in Fig. 26. The oil enters the annular groove between the vaporiser body and the plug forming the seating of the air inlet valve and passes down through a ring of small holes on to the face of the valve and is thus brought intimately into contact with the incoming air. The oil actually enters through holes in small steel plugs screwed into the terminations of the oil duct and these plugs can be changed so that different diameters of holes can be used to suit different grades of oil, and a further adjust-

ment can be made by blanking off a number of the holes. The ignition arrangements shown below the admission valve consist of a cast iron block with passages drilled in it, and is surrounded by an asbestos sheath which isolates it from the cover; this arrangement takes the place of the ordinary ignition tube and gives quite a uniform ignition under varying loads. Governing is effected by a hit-and-miss arrangement applied to the lever of the exhaust valve, which, when the engine exceeds the determined speed, holds the exhaust valve open until the speed again drops to normal. Up to 30 horse-power sizes, the engines are usually started by being pulled round by hand, but compressed air at about 150 pounds pressure is used for starting with the larger sizes. The engines are designed to work in the ordinary way with Russian refined petroleum (lamp oil) of 0.825 specific gravity and having a flash point of 83 deg. F. Abels close test, but most of the crude semi-refined and residual oils can also be used. Using refined lamp oil the consumption varies from about 0.65 of a pint per brake horse-power hour in the large engines up to 1 pint per brake horse-power hour in the smaller.

Besides the suction gas plant and gas engines already referred to, Messrs. Ruston, Proctor & Co. also exhibited a 40 horse-power crude oil engine of new design. This belongs to the class of engine where an external lamp is only used to heat the vaporiser up until the engine is started, the vaporiser afterwards being kept sufficiently hot by successive explosions. The general appearance of the engine reproduced from a photograph is shown in Fig. 27, and details of the arrangements for supplying oil are shown in Fig. 28. It will be seen that the oil pump, *A*, is horizontal and contains a plunger, *B*, which is worked by a quick-acting cam, *C*, on the half-speed shaft, the plunger having a non-metallic buffer, *D*, in its head to obviate shocks from

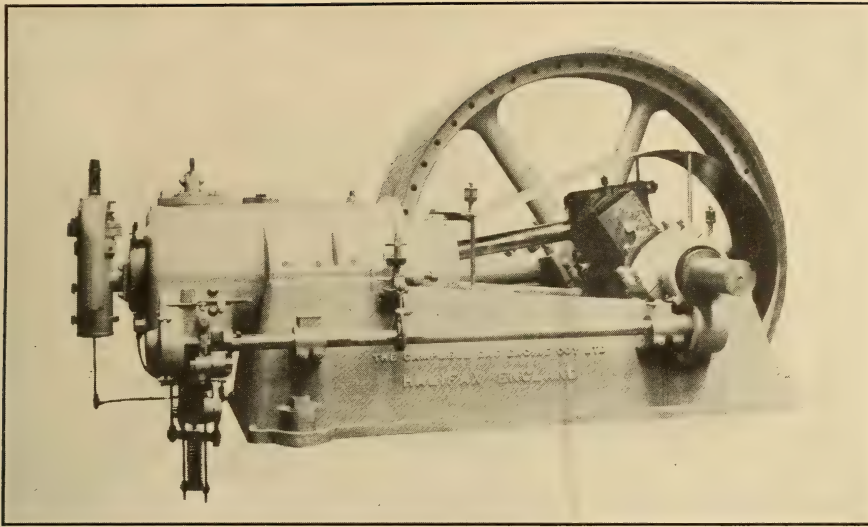


FIG. 29.—THE PETTER OIL ENGINE.

the sudden action of the cam. It has been found in practice that it is necessary to slightly alter the time of the spray injection, according to the density of the oil used and this can be very readily done in two or three minutes by advancing or retarding the position of the cam, *C*, on the layshaft by means of three setscrews. Regulation is effected by causing the governor to control a small by-pass valve, *e*, on the delivery side of the oil pump. The end of the stem of the by-pass valve rests on a lever *f*, which rocks upon an adjustable screw at one end and at the other end is capable of being lifted more or less by an eccentric pin, *g*, which changes its position according to the action of the governor. The fuel passes from the pump through a pipe, *h*, to the chamber, *l*, containing the atomiser in which is placed a duplex valve held down by a powerful spring, this valve being lifted with each stroke of the fuel pump. The valve is of two diameters, the smaller or needle valve portion of which, *j*, closes the entrance to the combustion chamber, *K*, and when the valve is opened the oil is forced through converging grooves, *l*, which

so split up the stream that it emerges in the combustion chamber, *k*, in a cone-shaped cloud of fine oil spray. The upper portion of the valve is furnished with a cylindrical head which is a sliding fit in the chamber, and at the upper side of the head is another seat, closing the outlet through which a pin passes and presses on the loading spring. The movement of the valve is only about $1/32$ of an inch and any leakage is practically stopped at the upper valve seat, and it has been found in practice that such oil as does pass is only what is needed for lubrication, but, at the same time, provision is made to return any possible leakage from the atomizer to the by-pass side of the pump by the pipe *Z*. The main inlet valve for the air is on top of the cylinder, while the exhaust valve is placed directly below and both are worked in the usual manner by a cam on the layshaft. The small valve *W* is the water snifting valve, and is pulled open during the suction stroke of the engine. The atomizer has a jacket, *K*, in which the water circulates on its back from the back end of the cylinder through the small horizontal pipes to the needle valve,

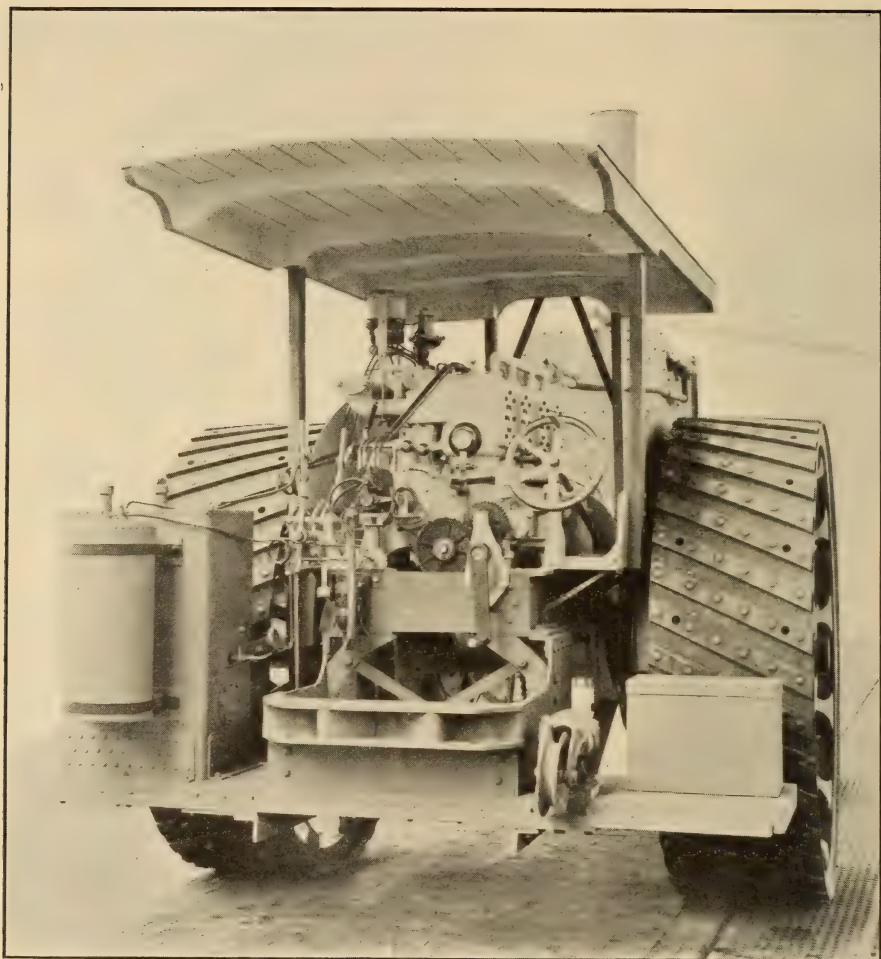


FIG. 30.—MARSHALL OIL TRACTOR.

Y, and it is possible by means of this valve, together with the sight hole, to regulate with certainty the quantity of water used. The piston and exhaust valve spindles are lubricated by means of an independent duplex force pump and the crankshaft and layshaft bearings by automatic oiling rings. Subject to very slight alterations, these engines will work on any grade of crude, residual or refined oil. As will be seen from the drawings, no independent air pump is used to compress the air in the cylinder and only the very moderate pressure of 270 pounds to the square inch is reached during the compression stroke. In some trials made by

Prof. Robinson on the first engine of this design constructed, the compression was 250 pounds to the square inch and the highest explosion pressure reached 425, the mean effective pressure varying from 70 pounds at full load to 40 pounds at half load. The amount of oil used under these conditions was 0.56 pound per brake-horse-power hour at normal load and 0.71 at half load. This was with Java crude oil and with crude Russian the consumption was only slightly greater. The makers stated that at Brussels the results had been improved on in the engine exhibited.

A paraffin engine of 50 horsepower was exhibited by Messrs. Rea-

vell & Co., of Ipswich, and was arranged to drive, through gearing, one of their standard type air compressors; and a small 4 horse-power petrol engine was also shown by Messrs. Bentall & Co., of Maldon (Essex), but neither of these exhibits calls for any particular remark.

Several different sizes of petrol oil engines were shown by Messrs. J. B. Petter, Sons & Co., of Nautilus Works, Yeovil, and an illustration of their 22 brake-horse-power horizontal type is given in Fig. 29. These engines worked on the ordinary Otto cycle and were fitted with a very neat arrangement of vaporiser with a variable oil and air supply directly under the control of a centrifugal governor. The vaporiser, which can be seen projecting from the back of the cylinder head, has what are practically two ignition tubes, the outer one of which is heated in the usual way at starting by a portable lamp, and when the engine starts running and the lamp is removed the inner tube is maintained at the requisite heat by direct contact with the exhaust gases. The governor controls directly both the oil and air entering and is driven by skew gear-

ing on the end of the half-speed shaft, which also works the exhaust valve below the cylinder and the auxiliary air inlet valve on top, and at the same time the small oil pump delivering fuel to the vaporiser. The oil valve has a very simple arrangement so that it can be adjusted to work with kerosene or crude oil. A certain amount of water is drawn into the cylinder during the suction stroke, entering with the auxiliary air supply, and the makers seem to lay special stress on this water injection, particularly as a means of exactly determining the moment of ignition. This plan of injecting water during the suction stroke is now adopted on a number of oil engines and, although it certainly apparently improves the running of the engine, there is still a certain amount of obscurity as to what part it does really play in altering the composition of the explosive mixture. No doubt numerous experiments have been tried on the same engines working with and without water injection, but the actual results do not appear to have been published.

Two examples of paraffin oil engines applied to traction purposes



FIG. 31.—GANG PLOUGH HAULED BY MARSHALL OIL TRACTOR.

were shown in the main Machinery Hall by Messrs. Marshall Sons & Co., Ltd., of Gainsborough. This firm has been engaged in building steam traction engines for the past forty years, and, therefore, when the internal combustion engine became eligible as a motive power they were already specialists in the design of the traction engine itself. The small cylinder one shown at Brussels was one of their two-cylinder, class E, which are now widely used for hauling ploughs and other cultivating implements, as well as taking the place of ordinary portable engines for farmyard purposes, or steam traction engines for road haulage. This machine remained until the close of the Exhibition, and was awarded a Grand Prix in class 35, but the larger engine was withdrawn and sent out to the Natal Government for military transport purposes. The illustration shown in Fig. 30 is a view of the driving end of a large oil tractor of the latter type having four cylinders and capable of working up to 60 brake-horse-power, and embodies all the features of the smaller sizes. The general arrangement resembles that of a powerful motor car with the gearing arranged to produce a maximum tractive effect instead of a high speed. A substantially braced frame of steel channels 9 inches deep carries the engine and the bearings for the necessary gearing. Power is transmitted from the engine through a metal-to-metal cone clutch, then to a three-speed and reverse gear, then to a differential countershaft, and ultimately to the hind wheels by means of spur gearing. The cylinders are 7 inches diameter by 7 inches stroke, and are cast separately, each having its own water-jacket, the valves being placed at the sides of the cylinders. At a speed of 750 revolutions per minute the engine develops 50 horse-power, and the gearing is arranged to give three separate speeds of 2, 5 and 7 miles per hour on the road. Ordinary

paraffin is used as a fuel, with an arrangement for starting with petrol. The paraffin vaporiser is of the maker's own design, and is kept hot by the exhaust gases on their way to the silencer and chimney. The ignition is of the Bosch high-tension type, with a self-starting device worked from a battery, which can be thrown out of action when the engine starts. The cooling water is circulated by means of a valveless pump, and a small vertical fan circulates air through the radiator. The two paraffin tanks hold about 115 gallons, and it is possible to travel 80 to 100 miles without replenishing either fuel or water supply. A simple form of Pickering governor regulates the speed of the engine by means of a throttle valve. Steering is effected in the usual way by means of a chain shaft and worm and hand-wheel, and two independent brakes are provided, one worked by a pedal and the other by a handwheel. The engines are fitted with an independent winding drum holding 100 yards of steel wire rope, which is led out fore or aft through large swivelling guide pulleys, one of which can be seen on the right-hand side of the illustration. Altogether, the arrangement seems to have been very carefully thought out to enable an oil engine to be used to the best advantage for this particular purpose.

The actual application of one of these oil tractors to hauling ploughs is shown in Fig. 31, which illustrates a Cockshot gang plough of 12-furrow size at work in Canada. Some very exhaustive trials at Winnipeg and other Canadian centres were held during the years 1908 and 1909, and it is somewhat gratifying to the English engineer to know that, amongst quite a collection of other gasoline tractors, the Marshall colonial tractor more than held its own.

Another example of the oil engine applied to tractive purposes was to be seen on the popular light railway which traversed the outlying portions

of the Exhibition grounds, as there the Gasmotoren Fabrik Deutz showed one of their Otto motor-driven locomotives coupled to an inspection car. Externally, the machine closely resembled a small steam locomotive; but the interior mechanism consisted of a horizontal oil engine placed longitudinally on wrought-iron frames and transmitting power to the driving wheel through a combination of friction clutches and chain drives, which enabled two speeds to be obtained in either direction. This arrangement of gearing seemed quite convenient to manipulate, and the engine always successfully climbed the hill leading to the windmills. Originally designed for underground mining work and quite narrow gauge track, the size of this locomotive has been gradually increased until they are now built with engines of 60 horse-power for working on ordinary 4-foot 8½-inch gauges, capable of handling on a level track 7,546 pounds at 2.5 miles an hour and 1,826 at 2.92 miles per hour. The makers give the following fuel consumptions, which are derived from some actual tests:

Under full load the consumption of fuel per effective horse-power per hour is:

	Pounds.
When burning gasoline.....	0.64 to 0.77
When burning benzol or crude benzol.	0.53 to 0.57
When burning alcohol	0.84
When burning petroleum	0.80 to 0.84

At Brussels tar oil or crude benzol was being used, and as this apparently could be obtained very cheaply locally, the running costs came out very low.

While the oil engines shown at Brussels fairly represented the various systems in general use, a good many leading makers did not exhibit. The well-known Bolinders type of engine, in which the fuel is

squirted into the cylinder against a hot bulb or some form of cavity in the head, was not shown, and the very original reversible Peck engine was also absent.

However, there was quite enough to be seen to convince anybody that the oil engine had entered a stage of very rapid development both for land and marine purposes, and, if the 600 horse-power marine engine shown at Brussels by the Amsterdam firm be taken as a starting point, it will be very interesting to see what sizes will be reached by the end of the next decade.

A 1,000 horse-power reversible, two-stroke Diesel engine has already been completed by the firm of Carels Frères, of Ghent, and during the very few months that have elapsed since the Exhibition closed projects for much larger sizes have been under serious consideration.

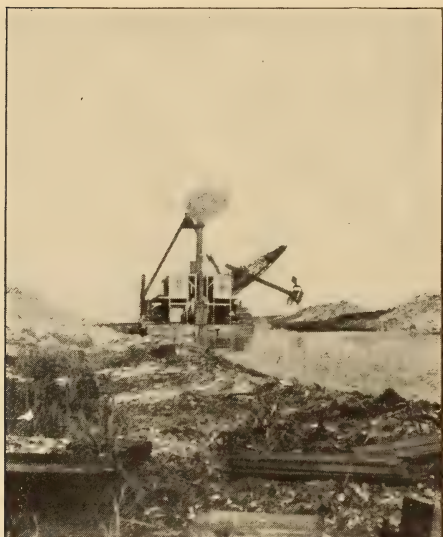
In conclusion, the writer would like to add one word as to the desirability of adopting some international classification of various fuel oils based upon their physical properties and chemical composition. When these oils were only to be obtained from a few producers the trade names served fairly well to indicate to the consumer what he was purchasing; but now, with the multiplication of the sources of supply, these designations have almost lost their significance, and the term "crude oil" is loosely applied to very different products. What is really wanted by people interested in the subject is a classification based on specific gravity, flash point, viscosity, percentage of sulphur, together with the calorific value, and it should be quite easy to frame a few simple code words which would give, in a condensed form, such information.

RECLAIMING THE EVERGLADES

HOW THE STATE OF FLORIDA IS WINNING MILLIONS OF ACRES FROM
THE WATER

By Day Allen Willey

There has been much attention directed of late to the great work accomplished by the United States Reclamation Service in recovering vast tracts of land by the irrigation of the arid districts of the Western States. The engineer is also turning his attention to the reclamation of great areas which are yet unavailable, not because of lack of water, but because of the presence of too much water. Following out his mission of directing the great sources of power in nature to the use and convenience of man, the engineer has taken millions of acres of the richest land in the world, and by draining off the superfluous water, is making the Everglades of Florida a region which, instead of being the swamp retreat of the remnant of the Seminoles, will become a source of vast and new wealth for the people and the nation.—
THE EDITOR.



DREDGING THE EVERGLADES

THAT long leg of the United States sticking out into the sea and separating the Atlantic from the Gulf of Mexico is a land of mystery. The geologist and the botanist have tried to get acquainted with it, but to this day no white man has been entirely through that southern portion of Florida which has been most appropriately called the Everglades. A tenth of Florida—more than 5,000 square miles—is under water, except for some islets where the cabbage palm tree shows there must be dry spots.

What the explorers have to encounter is the saw grass, or, as it might well be called, sword grass; for the blades, sticking from six to a dozen feet out of the water, have edges that cut like a knife. A row boat or canoe cannot be forced through it; it cannot be cut. One man worked his way a few miles into the stuff in the dry season by burning off the top, but he pierced only the edge of the Everglades.

Yet there are channels. How long the Seminole Indians have been paddling through them no one knows. By these channels they reach their settlements on the islands, and they may sometimes be seen in their canoes, floating out of a rift in the saw grass into the Miami or New rivers, going to the nearest town to barter skins, beads and feathers for cotton clothing and a good deal of bad whiskey. Then the canoes start homeward. Any attempts to follow them end in a game of hide and seek; up some opening they go.

The secrets of the Everglades, however, have at last been revealed in part. Scientific investigations have shown what is beneath these waters hidden by vegetation. The men with the transit and level have found the height of South Florida above the sea. Much work has been done in probing into this region, and it is known that, if the waters were drained from at least a part of the



VEGETATION ON AN EVERGLADES FARM



HOW THINGS GROW IN THE RICH SOIL OF THE EVERGLADES



A SCENE ON THE MIAMI RIVER, FLORIDA

surface, some of the most fertile soil ever turned over by the plow would be in reach of the farmer. The surveys show an agricultural empire that contains fully 5,000,000 acres—nearly 8,000 square miles—homes enough for a hundred thousand families, who can raise about anything that grows in the tropical or temperate zone.

Can the Everglades be drained? The engineers attempted to answer this question thirty years ago. Henry B. Plant and H. M. Flagler, who were pioneers in bringing the steel highway, thought of it. Disston, the millionaire saw maker, of Philadelphia, did more than think. He spent a half-million dollars in reclaiming land that produced the largest crop of sugar cane to an acre on record. Disston's work was done under a concession from the State of Florida, but the agreement of the State to advance its share of expense was not kept and the work stopped. Other plans were carried out in a small way, but it remained for the late Senator Broward, then Governor, to fit the key that will unlock the bar-

rier by which this tenth of the State is to be turned from waste to a land of plenty.

Napoleon Bonaparte Broward was not an engineer. He was a sailor by profession, and had what the novelist would call a romantic history. He gained considerable notoriety during the early part of the Cuban revolution as a commander of the tug *Dauntless* and the steamer *Three Friends*, with which he made voyages between Jacksonville and the coast of Cuba, carrying arms, ammunition and other supplies to the insurgents. That was the beginning of his fame and also of his political career. He next became known as an opponent of the trusts, and employed several lawyers and started a number of lawsuits with railroads, canal companies and other organizations over their titles to grants of land which had been made by the Legislature of Florida within the last half century.

His experience in filibustering gave Broward an intimate knowledge of the Florida coast. He made friends with the Seminoles, and, through them, obtained information about the



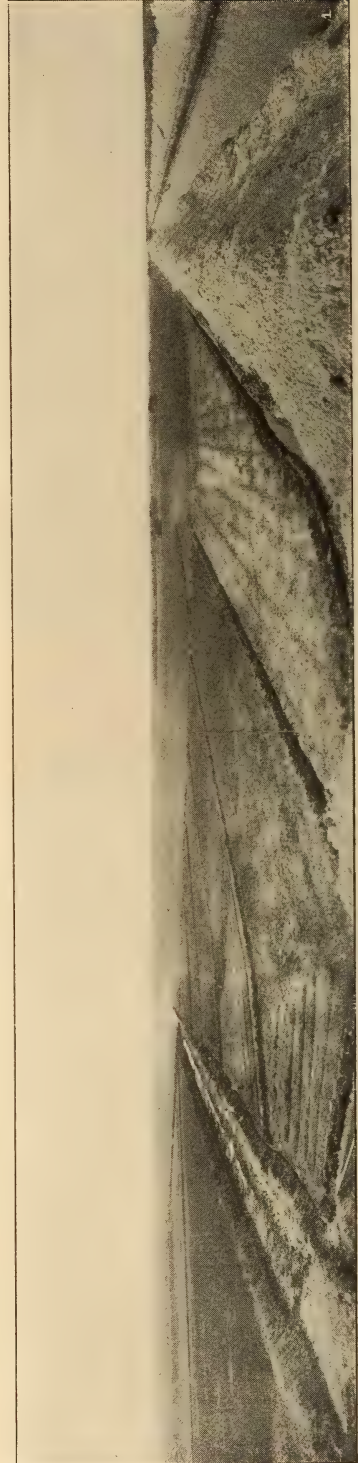
BANANAS GROWING ON THE EDGE OF THE EVERGLADES



A FIELD OF LETTUCE AND BEANS BY THE SIDE OF A DRAINAGE CANAL

direction of currents in the Everglades; also, about Lake Okeechobee, and how its waters were carried seaward. Broward made a careful study of the formation, with measurements to determine if the surface water of South Florida could not be carried off by canals, and the water of Okeechobee, which is the principal cause of the flooding of the Everglades, lowered by channels excavated to suitable dimensions. When he had finished his investigations Broward felt sure enough of his scheme, and made it the leading feature of the campaign by which he was nominated for Governor. As a result of his promise to voters that he would add millions of acres of farm lands to the State, thus increasing its wealth from the sale of farms and by settlement, he was elected Governor, and since has been carrying on the drainage plans with such success that engineers who have examined the work say it is practical; but the fact that 15,000 acres of the Everglades are now producing crops, the water drained off through the Broward canals, is, perhaps, the best proof that this filibuster promoter and politician meant what he said.

As to Governor Broward's views of what is the greatest single land reclamation yet undertaken in America, they may be expressed in an interview he gave the writer of this article: "To give a clear conception of how this work will be accomplished it will be necessary for me to refer briefly to the position of the Everglades and their character. They are sufficiently elevated above the sea to permit all of the surface water to be removed if an adequate system of outlets is constructed, while Lake Okeechobee can be kept at such a level that it cannot overflow the surrounding country, even when its feeders are filled with flood water. We do not expect to drain the lake. It is not necessary, and the task would be too great, for the lake's present area is about 650,000 acres; but we can confine its waters to their



A SECTION OF RECLAIMED LAND IN THE EVERGLADES. THE DRAINAGE CANAL IS AT THE RIGHT

normal area by carrying off the overflow through the canal system we are constructing. The Everglades lie in an immense basin, whose rim, probably of volcanic origin, is composed of coral and limestone rock. There are times when the surface of the Everglades is so slightly submerged that the rim is above the water, while during the flood season it may be partially or wholly covered. This barrier is what creates the Everglades, as but a small portion of the water can escape through it.

"Measurements made at various points by State and Government engineers show the elevation of the submerged lands is fully 20 feet above the sea at the lowest point, and there is a continual descent from Lake Okeechobee to tide water. Consequently, the problem to solve has been how to make passages through this rim which would be of sufficient capacity to allow the water it confines to find a lower level and thus escape. This was the problem that my associates and myself, the trustees of the Internal Improvement Fund,

have attempted to overcome. I have given such study to it that when I was nominated for Governor in 1905 I pledged myself to drain the Everglades and make this the main issue of the campaign. The project was taken up immediately after election. We had two dredges constructed from designs of my own. They began operation in July, 1906, at the head of what is called New River, about 20 miles from the city of Miami. The New River flows directly into the sea. Each dredge is excavating through the rim I have described a canal which averages 60 feet in width and has a depth ranging from 12 to 15 feet. So far, nearly 5 miles of each canal have been completed.

"To provide a complete drainage system will need about 600 miles of outlets. Most of this work, however, will be merely mud excavation. It is intended to pierce the rim at several other points with canals which will connect with tidal streams like New River, and the success attained warrants the undertaking.



A CANAL CUT THROUGH THE CORAL ROCK TO CONNECT THE EVERGLADES WITH THE NEW RIVER



DEEPENING A RIVER CHANNEL FOR EVERGLADES DRAINAGE

As the channels are dug, the surface water in the vicinity finds its way into them and flows seaward.

"Is it worth while to make this

region fit for human habitation? If anyone so questions, let him consider for a moment the benefit it will confer, not only on the South, but upon



A DRAINAGE CANAL IN THE CORAL RIDGE

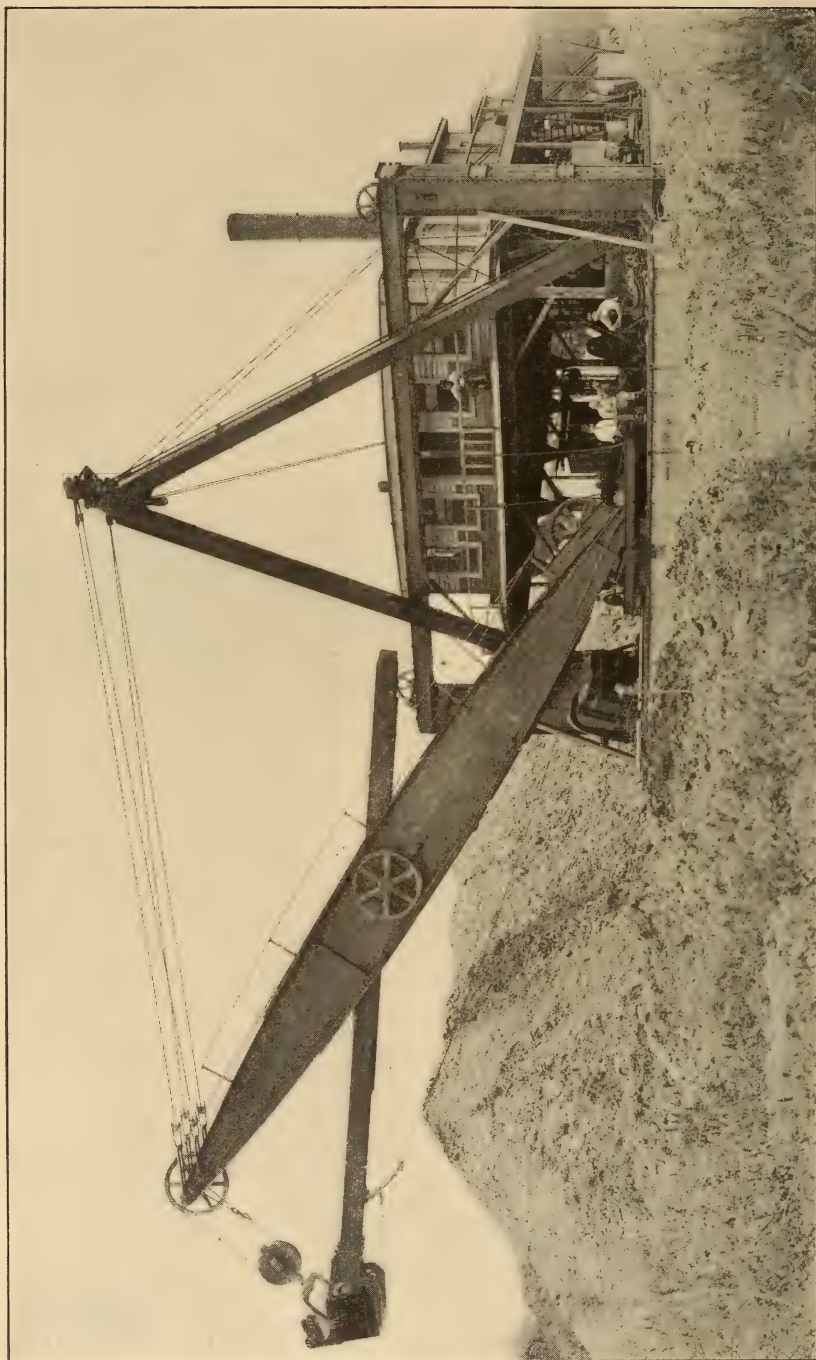


CUTTING THROUGH THE CORAL ROCK AND DEPOSITING IT ON THE EMBANKMENT

the whole country, from merely one standpoint. There is now imported into the United States more than 2,400,000 tons of foreign sugar, for which is paid, in duty and to the foreign producer more than \$150,000,000 yearly. Total exports per annum of the following articles, corn, wheat, flour, beef and naval stores combined, amounts to but \$144,000,000. In other words, more is paid in American money for foreign sugar than the people of foreign countries pay the people of the United States for all of the corn, wheat, flour, beef and naval stores shipped them from the United States. There are in this submerged portion of Florida 5,000,000 acres of land suitable for the cultivation of sugar cane, 3,000,000 acres of which land is free of trees and shrubs, containing only grass; 3,000,000 acres of muck land, varying in depth of muck from 2 feet at the edges to 20 feet in the middle. A small portion of

the territory, when reclaimed by private enterprise and cultivated some years ago, actually produced 63 tons of cane to an acre of ground—cane which yielded 12,600 pounds of sugar. If even 500,000 acres of this soil were put into sugar cane it would yield more than the 2,400,000 tons of sugar now annually imported into the United States.

“What has been already done in the raising of fruit and vegetables on the small areas of soil which have been drained by private enterprise shows that such work will be repaid many times. These 5,000,000 acres represent only a small portion of the swamp land granted to Florida by the United States on which millions of people might find homes and occupations if it were properly drained, which it is possible to do at a very small expense, considering the value of this land for settlement. Let me give a few statistics to further show the extent of this land, now a great

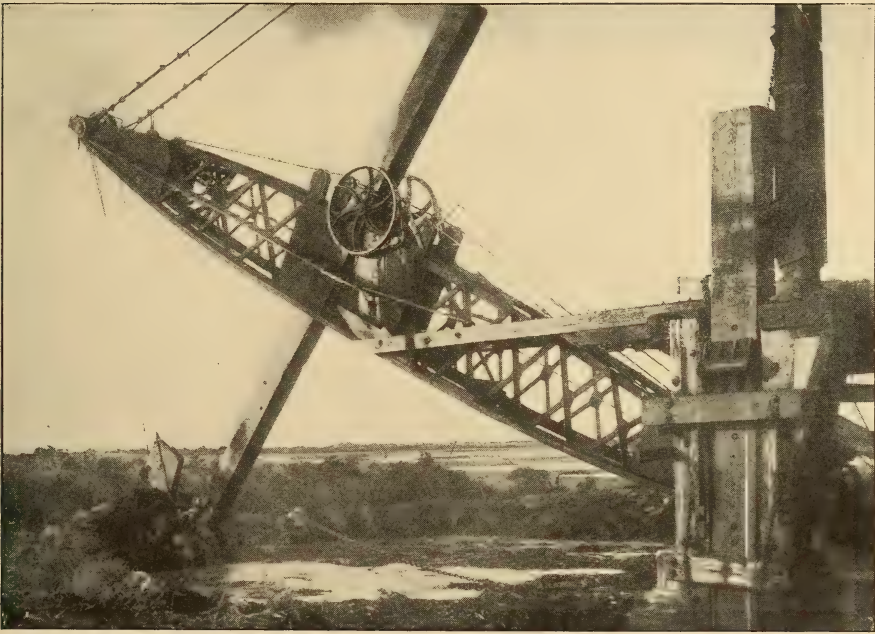


THE GREAT DREDGES IN THE EVERGLADES OFTEN CUT THEIR OWN CHANNELS, THE WATER FLOWING IN BEHIND THEM AS THEY MOVE FORWARD

waste, which might be made of such value. It covers a space equal to the total area of three States of the Union—Connecticut, Rhode Island and Delaware. Did not England reclaim the lands in the valley of the Nile? Then can we not reclaim the lands of Florida?

"Centuries ago the people of Holland found themselves cramped for room, because of the rapid increase of population. Instead of falling upon some neighbouring people and taking from their territory, they

decayed mountain top. The crest is formed of massive limestone, usually covered by a mantle of sand. In this formation are numberless pot-holes, which vary in size from a few feet to thousands of acres; also, countless lakes of fresh water, springs, and frequent subterranean streams and pools. A few miles north of Cape Sable is an outcrop of limestone which projects to Lake Okeechobee. In this outcrop is an extensive shallow basin, extending 130 miles north and south and about 70 miles east



CLEARING AWAY GROWTH IN AN EVERGLADES CANAL

built dikes, shut out the sea, pumped out the water, and to-day the bottom of the ocean has become the garden spot of Europe, the home of a multitude of happy and prosperous people. The Everglades, as I have said, are above the level of the ocean. So our only task is to let the water run out of them to make habitable a region which is one of the richest in the world and can be made one of the most productive in America."

One of the strange facts about this part of Florida is that it is really a

and west, while the altitude of its rim is 12 feet above mean low tide in Biscayne Bay and a little less above the Gulf of Mexico. This rim is from 3 to 12 miles from the ocean edge of the coastal plain on the east and an average distance of 50 miles from the Gulf on the west. So far as explored, it extends all around the edge of the basin, forming a complete cup. As a result of the weather and flowing water the rim has been worn into fantastic shapes. The depth of the basin varies from



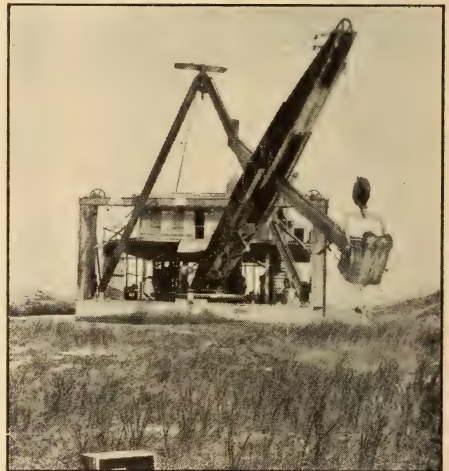
THE DREDGE MIAMI, CUTTING THROUGH A RIDGE OF CORAL 30 FEET HIGH

1 foot at the rim to as much as 12 feet in places, but generally the rock floor is from a depth of 1 to 6 feet. And here is the secret of the fertility of the Everglades. Above the entire rock floor rises a layer of muck, formed of an alluvial deposit and of decayed vegetable matter. This deposit varies from a few inches to several feet in thickness. The water covering this deposit comes from springs that, in turn, have their source in the lake.

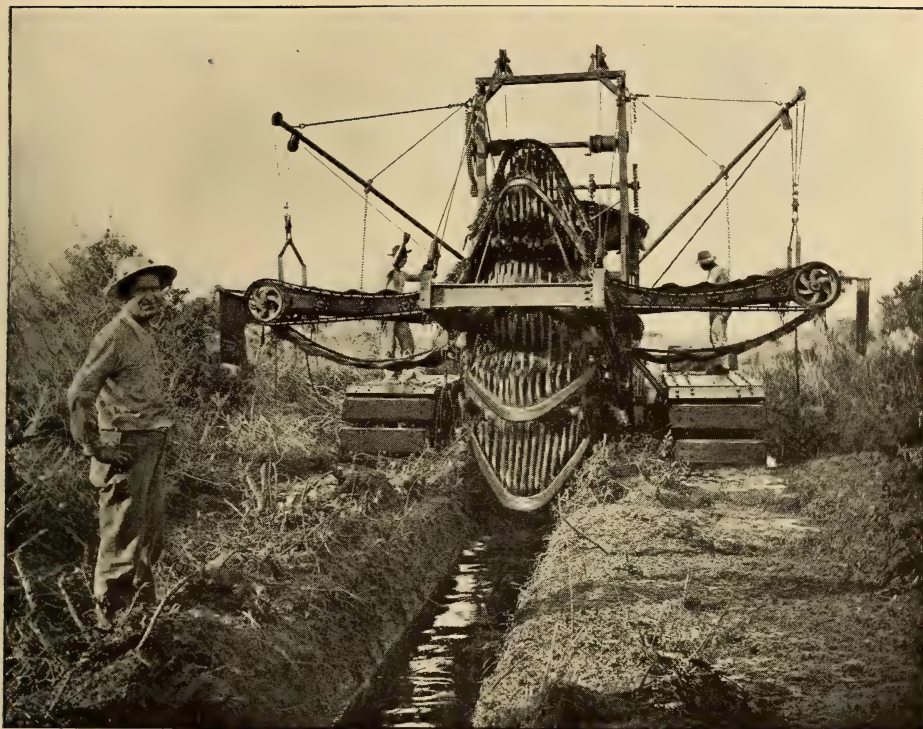
Governor Broward designed and built the dredges that began excavating the drainage canals six years ago. They were small in dimensions compared with the types which are now in service and to be installed, but what they accomplished proved that the greatest land reclamation project ever promoted is practical and will be a success. To-day the waters of Lake Okeechobee, the greatest flood source, are entering the sea, proving that the Broward scheme of canals having a natural outward flow was correct, not merely in theory, but in practice.

As a result of these operations, the attention of engineers and other experts has been drawn to the scheme. Their conclusions were that it meant a great mechanical achievement. It

would be impossible for any amount of human labour to accomplish even a beginning in this work, which is now being performed by only two types of excavating machinery—dredges and ditchers. Governor Broward increased his plant to four dredges before death ended his activity. The State Drainage Commission continued with his plans, which were to create a system of main drainage canals having a mini-



A DIPPER DREDGE IN THE SWAMP

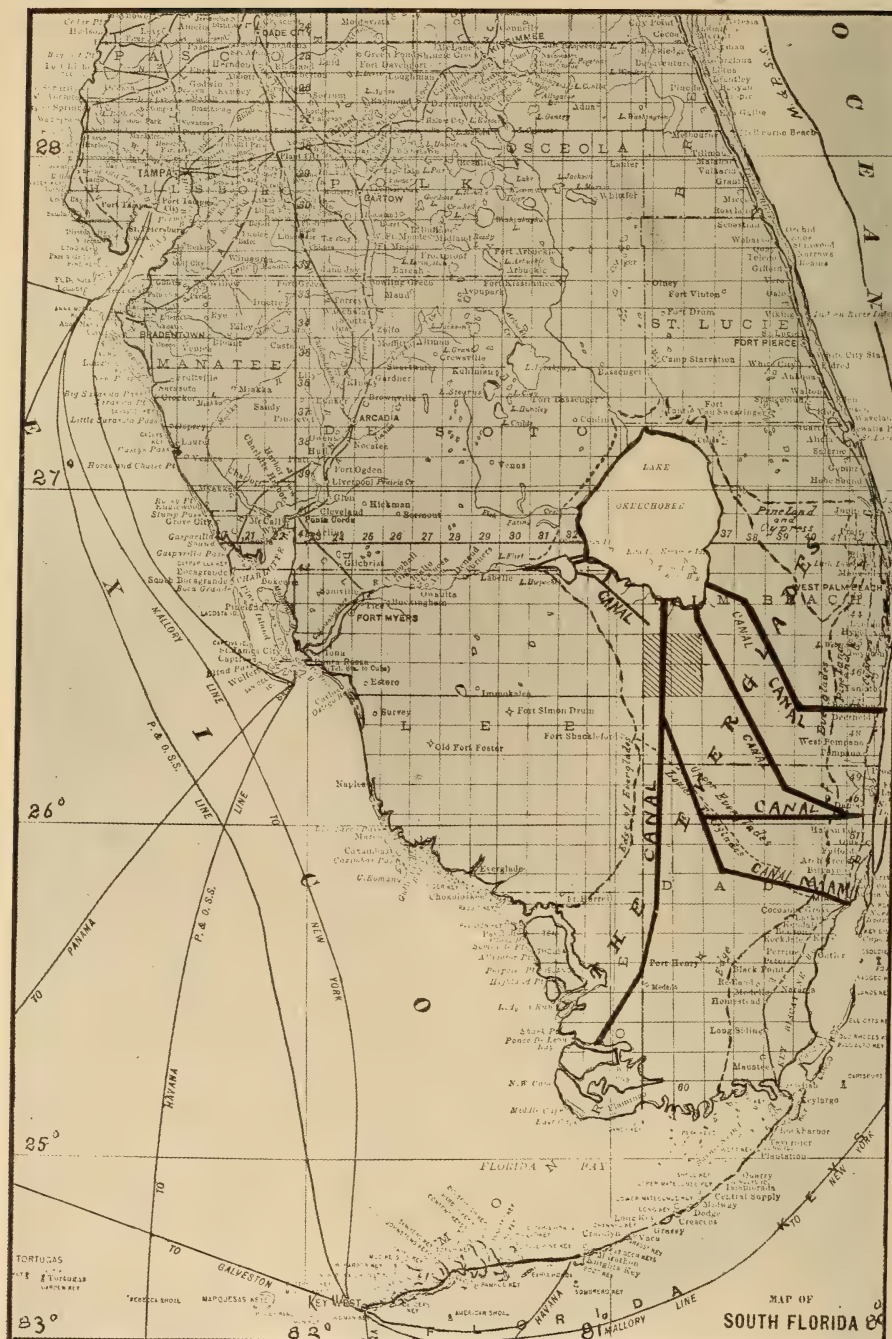


A DITCHING MACHINE AT FORT LAUDERDALE, EVERGLADES

num length of 113 miles, a depth of 10 feet and a width of 100 feet. But this will be only a portion of the series of outlets, extensive as it is. A contract has been let to the Furst-Clarke Company, of Baltimore, who are among the leading harbour improvement and canal excavating companies of the country. This corporation has made a thorough investigation, and, through its experts, has calculated the time to complete the work of lowering the waters of Lake Okeechobee so that they will be permanently restrained below its rock rim and the flooding of the Everglades checked.

It is only necessary to lower the lake to a level of 2 feet in order to prevent an overflow, and the present and future operations are based on this estimate, the dimensions of the canals and laterals being built according to this calculation. The magnitude of this work, however, can be

realized when it is remembered that over 1,000 square miles form the area of the lake and that it must be kept 2 feet below the flood level. The Furst-Clarke Company now have six dredges in operation. It has been found that, in addition to the coral rock which forms the rim around the lake at different points on the proposed canal system, other rock formation exists between the lake and sea-coast, in some places 4 feet above the bottom of the proposed channels. The engineers of the company who have made examinations report that 11,000,000 cubic feet of this formation must be removed before the drainage system is completed. Several of the dredges are built and equipped especially for rock work, as is shown by the illustrations. One of the largest is the Everglades. This dredge has a wooden hull 105 feet long, 38 feet wide and 7 feet 9 inches deep, with a draft of 5 feet. The



MAP OF SOUTHERN FLORIDA AND THE EVERGLADES

When the canals are completed, they will drain an area one-half as great as the entire kingdom of Holland and nearly four times the size of the Zuyder Zee. The water will run off by gravity, no pumping being required.



A SUCTION DREDGE, SHOWING THE REVOLVING CUTTER

boom is 70 feet long, and the dipper arm is 46 feet. It has a dipper of $2\frac{1}{2}$ cubic yards capacity for handling rock and one of $4\frac{1}{2}$ yards for handling earth. The main engines are 14 by 20 inches, the swinging engines 10 by 12 inches. The boiler is of the

Scotch marine type, 9 feet in diameter and 12 feet 9 inches long. The bucket is reinforced by a set of large steel prongs, or teeth, with which the rock is torn away.

The Okeechobee is equipped not only for rock excavation, but for



THE OKEECHOBEE, ONE OF THE OLDER DREDGES OPERATING IN THE EVERGLADES

handling soft material as well. Its cutting or dipper bucket has a capacity of $2\frac{1}{2}$ cubic yards, while the earth bucket can excavate $4\frac{1}{2}$ cubic yards at one load. It is of the same size as the Everglades, and is of about the same horse-power. A steel dredge, also utilized for rock work in ordinary excavation, is 100 feet long, 42 feet wide and 7 feet deep. The boom is $61\frac{1}{2}$ feet long, and the dipper arm is 48 feet. It has a dipper of $2\frac{1}{2}$ yards capacity for rock and one of 4 yards capacity for earth. The main engines are 12 by 16 inches, and the swinging engines 8 by 8 inches. The boiler is of the Scotch marine type, 9 feet in diameter and 12 feet long. Another type has a steel hull 80 feet long and 40 feet wide and 5.5 feet deep. The boom is 62.5 feet long and the dipper arm 48.5 feet. It has a dipper of $2\frac{1}{2}$ cubic yards for rock and one of 3 cubic yards for earth. The main engine is 10 by 18 inches and the swinging engines are 8 by 10 inches. The boiler is also of the Scotch type, 8 feet in diameter and 15 feet long. These are the dredges constructed according to the plans of Governor Broward.

The excavators were taken over by the Furst Company, and have been in operation for some time. The company, however, has recently completed a new dredge, and two others are under way. The design of the completed dredge is an original idea with the engineers. It is a very powerful machine, developing no less than 150 horse-power. This is not only used for removing rock, but for excavating in the earth formation and cutting canals through the vegetable covering of the Everglades. It is equipped with a dipper bucket which has a capacity of 2 cubic yards and is provided with steel teeth for cutting into the coral. The dredge is so planned that the dipper and the suction pipe are operated from the same arm. The suction pipe has what is termed a revolving cutter head, and is forced through the water growth

and mud, carrying the material in a liquid form through the hull and depositing it on the bank of the excavation. The suction apparatus is operated by a 12-inch pump, and has a capacity for removing 6,000 cubic yards in ten hours.

Another dredge, which will soon be in operation, has an engine of 100 horse-power, and is to be used for hard formation entirely. It has a bucket of a capacity of $2\frac{1}{2}$ cubic yards, and is one of the most powerful types of dredge which has thus far been constructed.

For the making of smaller drainage channels the Buckeye traction ditcher is being installed in the Everglades. A type of these is on the project of the Everglades Land Sales Company, of Chicago, and was made in the Buckeye Works, at Findlay, Ohio. One machine, which is being operated at Fort Lauderdale, is a type of the capacity and power of this mechanism. It has a record of cutting an open ditch, 24 inches bottom, $4\frac{1}{2}$ feet top, $4\frac{1}{2}$ feet deep. This machine has dug 1,200 linear feet of ditch in 2 hours 5 minutes, and it has shown a capacity of 12 linear feet per minute cutting the same depth. It is actuated by a motor using gasoline for fuel.

What does this scheme of mechanical drainage mean in converting waste into producing soil? The figures given by Governor Broward convey an idea of what 5,000,000 acres may yield annually in crops. What the farmer has already raised on lands drained by private enterprise is shown by the fact that, from a single acre, has been grown a crop of fruit or vegetables, or possibly sugar cane, ranging in value from \$200 to \$1,000. Multiply the small figure by five millions and the sum seems incredible—a thousand million dollars. But the men who have been investigating the extent of the land area that may be reclaimed for farms disagree with the figures of the Department of Agriculture. The estimate of Mr. Frank Furst, head of

TERMINALS FOR WATER-BORNE FREIGHT

MINOR TERMINALS FOR INLAND WATERWAYS

By H. McL. Harding

It is now beginning to be understood that the weak element in the transportation problem lies in the high cost and low efficiency of terminal handling. It has been conservatively estimated that for any distance under 250 miles the terminal costs are as large as the transport charges, and that it is in the reform of the primitive terminal facilities that further cost reductions are to be effected. Mr. Harding discusses one of the reasons for the low efficiency of river transport, and his paper may well be considered also in the light of its bearings upon the far wider question of the notorious defects in railway terminals, even of the latest construction, both for passengers and for merchandise.—THE EDITOR.

SUCCESSFUL transportation upon inland waterways depends largely upon the terminals. It should be remembered that "Channels alone do not give transportation."*

In a good water terminal there must be: "(1) Properly designed and equipped piers; (2) Warehouses arranged for the mechanical handling of all kinds of freight; (3) transshipping machinery, and (4) Railway connections"; and, in addition to the above, there should be transshipment basins, which correspond to the transfer stations of the railways. The transportation by railways has been the result of the development of years and has received careful study by the most skillful engineers, which, with the single exception of the replacement of manual labour by machinery at terminals, has produced the most efficient methods for facilitating transportation. Both railway and steamboat companies are concerned in the movements of all kinds of freight, and in the transference from one carrier to another, and in the receiving and discharging freight at terminals. Whatever methods the railways have worked out successfully through years of experience which are adaptable to water-borne freight should be adopted and made part of water transportation. It is interesting to note how many methods of the rail-

ways can be adapted to water-borne freight.

PIERS OR WHARVES

A careful study of the Mississippi river and of its tributaries and the diagrams of the army engineers, shows plainly that there are many locations along the banks which are suitable for wharf terminals and many that are not. What is true of the Mississippi is also true of many other inland waterways. All unfavourable locations should be avoided wherever possible. Attention should be given to the character of back country or hinterland in selecting positions for wharves.

It is not merely sufficient to have solidly constructed piers at the principal cities, but there should be many intermediate ports of call with landings. The piers at the large cities should be planned in reference to the large amounts of freight which would there be handled.

Between the principal cities there should be a large number of inexpensive wharves or piers, and the details of their construction should be worked out carefully by engineers. Those places where the conditions are most favourable for permanence, small maintenance and the least cost for original installation should receive preference.

As an evidence of what has already been done, there are some excellent wharves in New Orleans, although for many years it was supposed that

* Herbert Knox Smith, U. S. Commissioner of Corporations.



A LOCAL PASSENGER LANDING ON THE MISSISSIPPI

A very pleasant situation in fair weather, but almost impracticable when the clay bank becomes a mass of mud.

the levees were the only possible terminals. In many places along the Mississippi wharves have already been constructed, and, based upon the experience with these, cheap, inexpensive terminals can thus be provided.

Corresponding to the large stations of the railways there should be large water terminals at cities; but, wherever there is a demand, as on the line of railroads, there should be small freight stations along the river bank.

By the railways, the expense of the side tracks, of the buildings, are made proportional to the amount of possible traffic. It is, however, noticeable that, in some cases, they have a small station house, even on the Far Western prairies, where there may not be more than a few structures within sight. They build for the future, realizing that the station

will be the nucleus around which will gather a settlement.

The steamboat lines should imitate them in this respect and provide a pier, a freight house, a waiting-room and an office for the agent. Arrangements can generally be made whereby there will not be a fixed heavy expense for this station agent, who should have other business until his whole time can be profitably occupied with the business of transportation. These piers or wharves should be designed in the very beginning, so that freight-handling machinery can be so installed as to be efficient.

WAREHOUSES

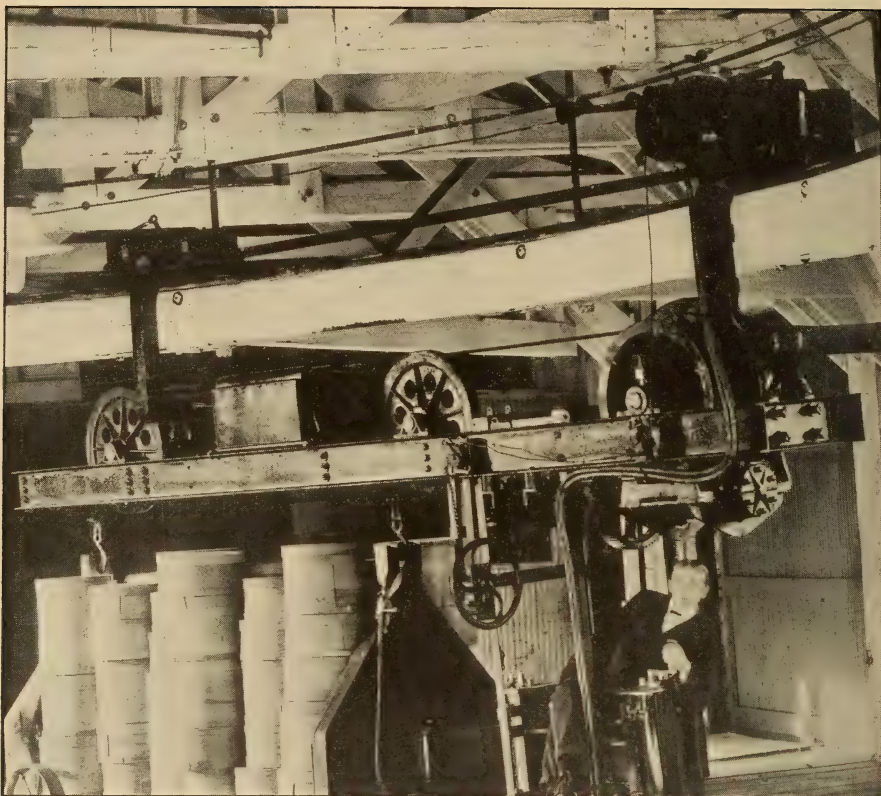
There should be upon the river bank, high above the greatest height of the river at flood time, warehouses solidly constructed, so as to protect freight from the weather. If

necessary, the floors should be elevated, as by means of overhead conveying machinery the raised floor will be of no disadvantage in the freight handling. There should be ample floor space, so that the different consignments can be kept separate and thus easily obtained by the consignee without delay and confusion.

By constructing these storage warehouses back upon the land and not upon the wharf structure, room for separating the consignments can be obtained, the cost of the wharves will be greatly reduced, and there are many other advantages, both in the facility of receiving and delivering the freight.



TELEPHER SYSTEM HANDLING CASES OF MERCHANDISE



AN OVERHEAD TROLLEY SYSTEM FOR WAREHOUSE SERVICE

It would be well to have a light roof over the wharf and an enclosed portion for temporary protection and the holding of goods which are to be reshipped.

On most of the inland rivers there are great variations in the height of the water. There is often a difference of 40 or 50 feet, or even more, between extreme low and extreme high water. The wharves must be so constructed and mechanically equipped that the loads can be transferred between the vessel and the wharf or warehouse as rapidly at the lowest as at the highest water. This hoisting and conveying must all be done by mechanical methods, using no manual labour in this freight transference.

The following extracts from the Report of the Commissioner of Corporations of the United States for

1910 on Transportation by Water will give some idea of the excessive cost of handling material by the present crude method.

"The crew on deck, which leaves port on boats, and is commonly termed roustabout, has gradually increased his wages on the tributary boats; formerly \$40, now \$90 per month; on the New Orleans, Bayou Sara and coast packets, formerly \$60, now \$90 to \$120 per month; and these figures are net, as all crews are fed on board at the boat's expense. The roustabouts neither load nor unload boats at New Orleans; this is done by the 'longshore or levee labourer. Labour on levee, to handle cargoes shipped out of New Orleans, formerly receiving 25 cents per hour now get 30 cents. Discharging on levee of incoming cargoes, on cotton was formerly 6 cents per bale and is



ROUSTABOUTS LOADING A MISSISSIPPI BOAT

These men must be carried on the boat, being paid and fed for their full time. One of the most expensive kinds of labour employed anywhere.



DECK CARGO ON A MISSISSIPPI BOAT

This shows how readily the merchandise could be handled by machinery instead of manual labour.

now 9 cents, and all other classes of shipments in the same proportion."

After the bags are stacked up on the boat the roustabouts sleep, play craps, etc., doing no work until the next terminal is reached. This may not be for several hours; but the wages, like interest and taxes, still go on. There is no manual labour in what might be called the civilized world which is so expensive.

By selecting the location with care,

they are at present, and the shipper and consignee would know that his goods would be carefully handled, properly cared for, and skillfully stored. The way-bills and all forms of receipts should be simple and such as to require the minimum of writing. Everything should be done to reduce the friction of transference.

On account of the short time needed to discharge or load freight where machinery has been intelli-



A GANG OF ROUSTABOUTS, THE MOST EXPENSIVE LABOUR IN THE CIVILIZED WORLD

properly constructing these wharves at intermediate stations, and equipping with machinery, the cost of which should be proportional to the work to be done, the expense of handling the freight would be reduced to a minimum, and the time to load and unload would be reckoned in minutes rather than in hours. The difficulties and expense of securing manual labour would be avoided, the breakage and other damages from losses would be a fraction of what

gently installed the same piers could be used by many steamship lines without interference. They should be owned by no private company, but rather owned or controlled by the State or municipality. This is possible until such time as there would be a very large amount of freight passing over these wharves, and then there should be a method of leasing which would not give a monopoly. The maintenance of terminals should be provided for in the same way as



A PRIMITIVE FREIGHT TERMINAL

This is an example of the crude methods used for handling merchandise on Western rivers.
The turbulent stream is already undermining the bank.

with roads or bridges. It seems that, if the United States Government provides the channels and their maintenance, the States or cities interested should provide and properly equip the terminals. This is the foreign method, and is the result of long experience.

The growth of the municipality, the development of the surrounding country, the increase of population, all depend directly upon transportation, and not only upon transportation, but upon cheap transportation.

If the manufacturer and the farmer can send goods or products at a low cost to the best market, they have a greater incentive for increasing the size and number of factories and putting more land under cultivation.

The following quotations from noted authorities confirm this statement:

Mr. J. Paul Goode, Professor of Economic Geography of the University of Chicago, says:

"Up to the limits of the oppor-

tunity offered by its hinterland, a city is great in proportion as it develops the facilities for the flow of commerce and reduces the friction incident to the breaking of bulk and the change in the character of the agent of transportation."

Professor William Z. Ripley, Professor of Economics at Harvard University, says: "The very existence of the city as a commercial centre may depend upon transportation competition between different cities." This emphasizes the necessity of modern port facilities and machinery.

"The cost of transportations is the factor which determines the distance from which raw material for manufacture can be drawn, and to which finished products can be shipped."

From the Report of the Metropolitan Improvements Commission, in Boston, I can do little more than refer to the headings of the chapters, with a few quotations, as indicating the trend of the contained suggestions:

"The Commercial Future of the City is Dependent Upon its Port Facilities."

"Transportation Efficiency is a Terminal Problem."

"The main purpose is to secure an adequate development of terminal facilities for the transfer, delivery and distribution of freight."

Again quoting:

"He who can most economically and quickly reach the markets of the world can control the commerce of the world. A decrease in transportation expense not only facilitates commerce, but creates commerce and manufacture."

Quoting from Mr. William C. Brown, president of the New York Central Railroad, he says: "The

function of transportation, so inseparably interwoven into our national commercial fabric, so vital to national prosperity, should be the subject of the most profound study by men of the highest order of intelligence, integrity, courage and conservatism. The cost of transportation reaches every man, woman and child that wears clothing and eats food."

In the judgment of the writer, it is of even greater value to a community to provide proper public waterways terminals than even to provide good roads, not meaning that roads should be neglected. It should, however, be understood that these terminals and the use of the warehouse and the machinery should be



THE RIVER TERMINAL AT ST. LOUIS

The river packet is moored beyond the wharf-boat, through which the merchandise is delivered to the levee shore. The freight must be piled on the river bank, to keep the wharf-boat clear for the teams.



THE MISSISSIPPI RIVER AND THE PACKET BOAT. COMPARE THE POSSIBILITIES OF THIS AND THE
GERMAN RIVERS

common to all, under proper restrictions, who wish to use them, and whatever charges should be made should be only for the actual outlay—that is to say, the actual expense for handling the freight. The maintenance should be provided and not be charged, for the present, against the various vessels using the wharf, as this is liable to abuse, the maintenance often being an unknown quantity. There is nothing in the installation of these terminals to prevent an individual steamship line building and equipping its own terminals, but there should be sufficient public terminals, as above outlined.

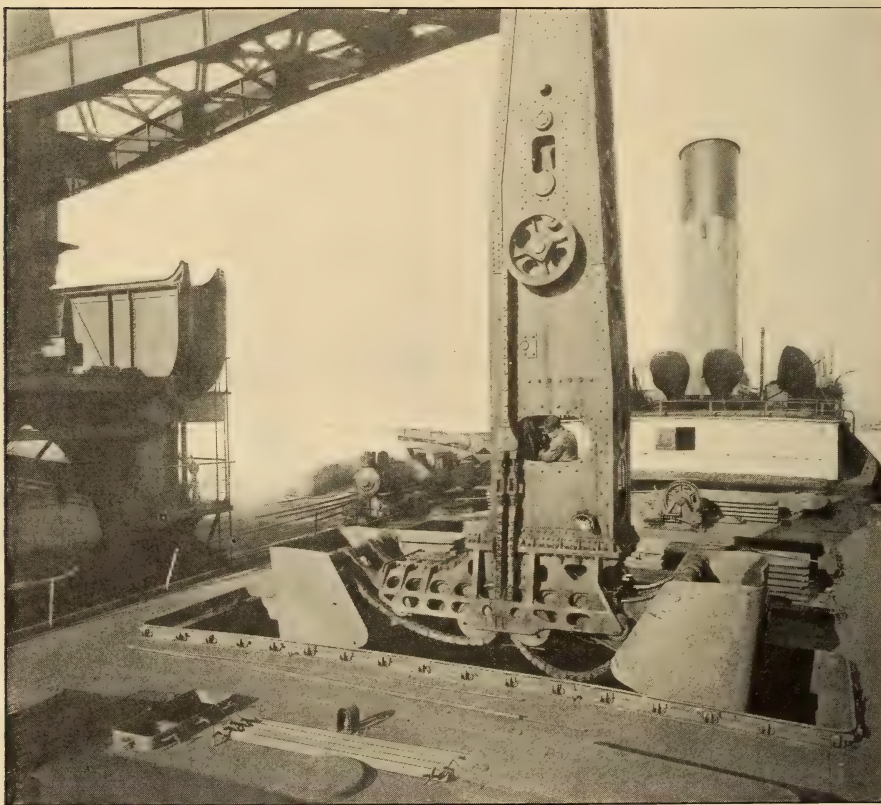
At these smaller terminals, besides the warehouse, which should, if possible, be constructed of concrete, there should also be enclosed open spaces for the storage of goods which are not affected by the weather, as

naval stores, barrels of different kinds of liquids and other material. This enclosed open space, as well as the interior of the warehouse, should be served by transshipment machinery, which, by means of movable tracks, should be able to handle freight upon any square foot of space without manual labour. The machinery should do all this work and both separate and tier the freight in piles for later movements. The freight for one consignee, instead of being placed upon the floor, should be placed upon "flatboards," which consist of sections of boards and provided at the corners with eyebolts, to which the hooks of the overhead carrier can be attached and the whole load raised as one unit and transferred either to the vessel or to the waiting drays of the consignee. In the same way the freight upon the vessel is placed upon these flatboards



AN ORE DOCK ON THE GREAT LAKES

The ore is dumped into the hoppers from the cars, and from the bins into the boats entirely by gravity.

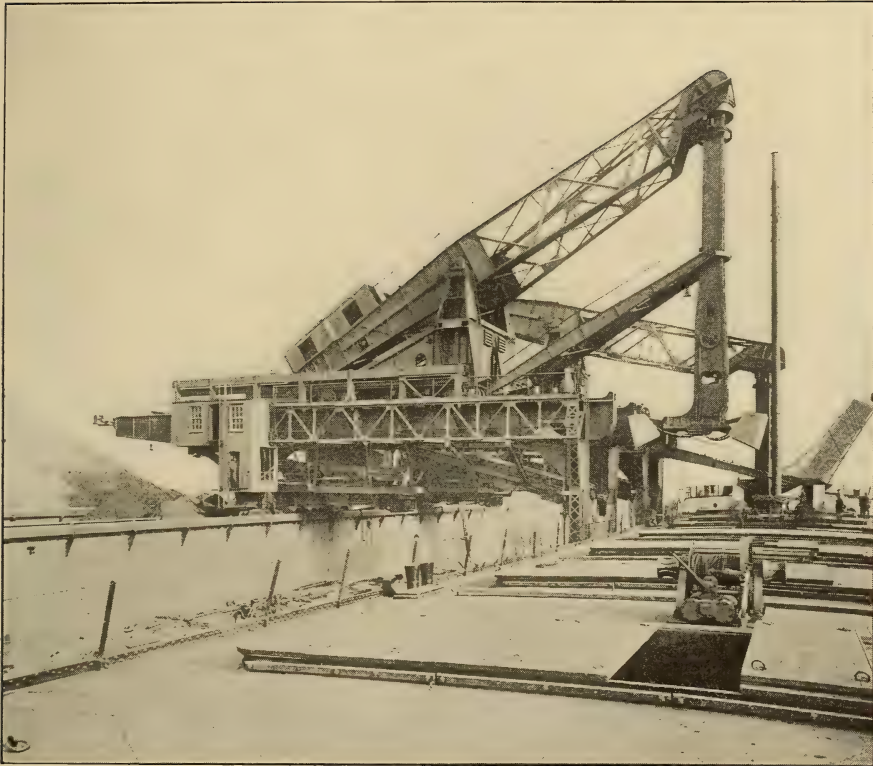


GRAB BUCKET FOR HANDLING COAL AND IRON ORE ON THE STEAMERS OF THE GREAT LAKES.
WELLMAN-SEEVER-MORGAN COMPANY

in the vessel, and when the vessel comes to the side of the wharf the hooks of the overhead carrier are fastened to the eyebolts of these flat-boards and the load raised as a unit and transferred to the wharf, the warehouse, or the yard space. There should be a number of these overhead carriers, so that there should be no delay in waiting for the return

TRANSSHIPPING MACHINERY

The layout, form and construction of transshipping machinery will vary, depending largely upon local conditions, the amount of freight that may be handled, and the amount of money which should be invested at the freight terminal. This is an engineering problem and should be so considered. The power is electricity,

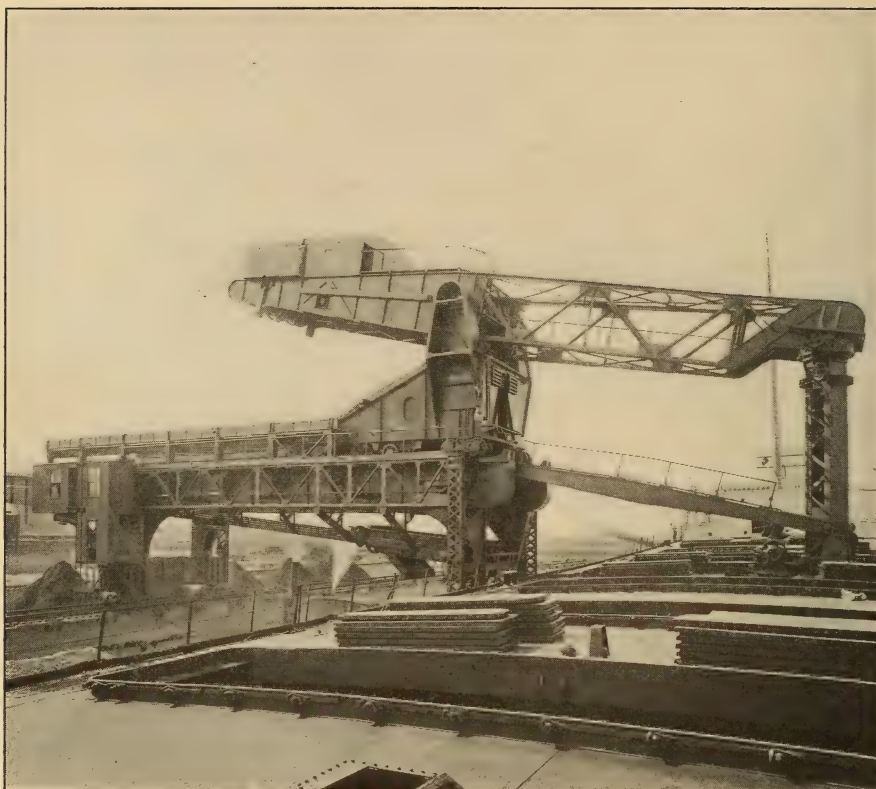


ONE OF THE LARGEST ORE UNLOADERS ON THE GREAT LAKES; THE BUCKET CAN GRAB FIFTEEN TONS OF ORE.
WELLMAN-SEEVER-MORGAN COMPANY, CLEVELAND, OHIO

conveyor. In the place of the flat-boards nets or other forms of carriers can be equally well used, but provision must always be made for the quick transference of freight between vessel and shore.

These warehouses should be planned by the architect so that the design and construction will provide for other methods of handling freight than manual labour.

and can be supplied either from the dynamo of the vessel, or, where there is a small amount of freight, the dynamo can be attached to a small gasoline engine and be started with no more difficulty than in "cranking" an automobile, and can readily be attended to by the station agent. Where overhead conveyors are used, a steamboat winchman makes an excellent operator. There can be sev-



UNLOADING BUCKET REACHING FOR ORE IN THE HOLD OF THE VESSEL. WELLMAN-SEEVER-MORGAN CO.

Bucket apparatus of this kind is especially useful for handling merchandise in bulk, upon the principle that maximum efficiency demands maximum loads.

eral kinds of carriers, or the same carrier can be adjusted both to handling miscellaneous freight of all kinds, and also to make use of the clam-shell bucket for handling bulk material, such as coal, ore, sulphur, etc., which can be transferred back to the enclosed space upon the shore.

It should be remembered that by properly adapted transshipping machinery it costs little more to transfer the freight 500 feet than it does 50 feet.

RAILWAY CONNECTIONS

By means of conveying machinery the freight can be transferred without any rehandling to cars upon railroad tracks, or to the railway station or warehouse, even though it be located at a considerable distance

from the wharf. The transference being all overhead, the machinery takes up no ground space, and can pass over tracks, railway cars, or similar obstructions, which often prevent easy movements between wharves and buildings in the rear of the railway tracks.

It is impossible in a short space of an article to explain all the details, especially as it is an engineering proposition, and should be carefully studied for each individual installation. It is, however, sufficient to say that freight, without any rehandling, can be transferred from a properly designed steamboat to the wharf, to the warehouse, to the freight car, to the freight station, or to warehouses back from the river bank at a surprisingly slight expense

and with great rapidity. Likewise, freight can be transferred in the reverse direction to the vessel. The interest and amortization costs of such machinery would be less than two cents per ton handled.

Whenever a new intermediate terminal is to be located there should be prepared a preliminary engineering report, describing the permanence of the bank and the history of the channel opposite the proposed terminal for many years past, the form and cost of wharf structure most suitable, the cost of transshipping machinery installed, the expense of operation and maintenance, suggestions as to the warehouse, sheds and yard, and also the best way to connect with the railways for mutual freight transference and general co-ordination.

Fortunately, by the use of modern

transshipping machinery the cost of piers can be greatly reduced; in fact, it can, within reasonable limits, be made proportional to the quantity of the freight to be handled at that particular terminal.

It is now only necessary at the smaller terminals to construct a foot walk and the uprights for supporting the conveying machinery. The freight is conveyed directly between the vessel and the shore. The small cost of the horizontal transporting movement being not more than one cent per ton, and the speed of 800 to 1,000 feet per minute, obviates the necessity of placing or holding freight upon the pier.

The previous description of mechanical methods refers largely to the handling of miscellaneous cargo freight.

The illustrations show the latest



A FULL COAL CAR BEING RAISED, INVERTED AND DUMPED INTO OTHER CARS ON THE TRACK BELOW

methods of unloading bulk cargoes, such as ore and coal.

This machinery accomplishes the unloading of a 10,000-ton cargo of ore within a few hours and at an expense of about three cents per ton.

Formerly when manual labour was, with wheel-barrows, employed, it cost 35 cents per ton. Where it

once would have cost \$3,500 to unload 10,000 tons, the same work can be done for about \$300.

In loading, the ore passes by gravity from elevated hoppers directly into the hold of the vessel, no machinery being required. The railway ore cars pass upon the top of the hopper structure and are filled by dumping the ore cars.



THE RAILWAYS OF BRAZIL

XII.—THE PARANA SYSTEM OF THE BRAZIL RAILWAY COMPANY

By Lionel Wiener

We have already discussed the Sorocabana system of the Brazil Railway Company, and examined the manner in which this was formed from the union of two older properties. The present article treats of another division of the Brazil Railway, and shows the extent to which it is controlling the transportation service of a large portion of the country.—THE EDITOR.

THE main line of the Parana Railway runs from Ponta Grossa, on the Sao Paulo and Rio Grande, to the harbour of Paranaguá, on the seashore. The line was built by a Franco-Belgian Company bearing the rather pompous title of "General Company of Brazilian Railways." This company constructed 25 miles of road to Morettes, at the end of the bay, in 1883, in addition to which a short branch of 10 miles in length was built to Antonina, along the farther side, in 1892. In the meantime, the formidable Serra barrier having been reached at Morettes, it became the intention of the company to run to Curitiba, which lies on the plateau, beyond the hills. This has been successfully accomplished, and the line, which was opened in 1885, is, perhaps, the finest in the whole of Brazil.

Porto de Cima is 6.3 miles beyond Morettes, but is 738 feet higher, while Roca Nova is 2,370 feet higher, although only 6 miles distant, there being thus a rise of more than 3,000 feet in a run of but little more than 12 miles. This required grades of 1 in 30 and curves of 300 feet radius, and all the skill of the engineer was demanded to reach the highlands. This portion of the road includes fifteen tunnels, sixty-four viaducts, and an average of 327 cubic feet of cutting per running foot of line. The route is very beautiful, containing most magnificently tumbled scenery, looking away down to the sea, glittering in the distance.

Curitiba was joined to Ponta Grossa, on the Sao Paulo and Rio Grande, in 1892, and at the same time there were built two branches, from Serrinha to the town of Rio Negro, at the upper end of the navigable stretch of that river, and from Restinga Secca to Porto Amazonas, the point to which the Iguassu boats ply. The system thus comprises:

Paranaguá—Curitiba (main line).....	69 miles
Curitiba—Ponta Grossa (main line).....	119 miles
Serrinha and Rio Negro (branch).....	55 miles
Restinga Secca—Porto Amazonas (brch.)	6 miles
Morretes—Antonina (branch).....	10 miles
	259 miles

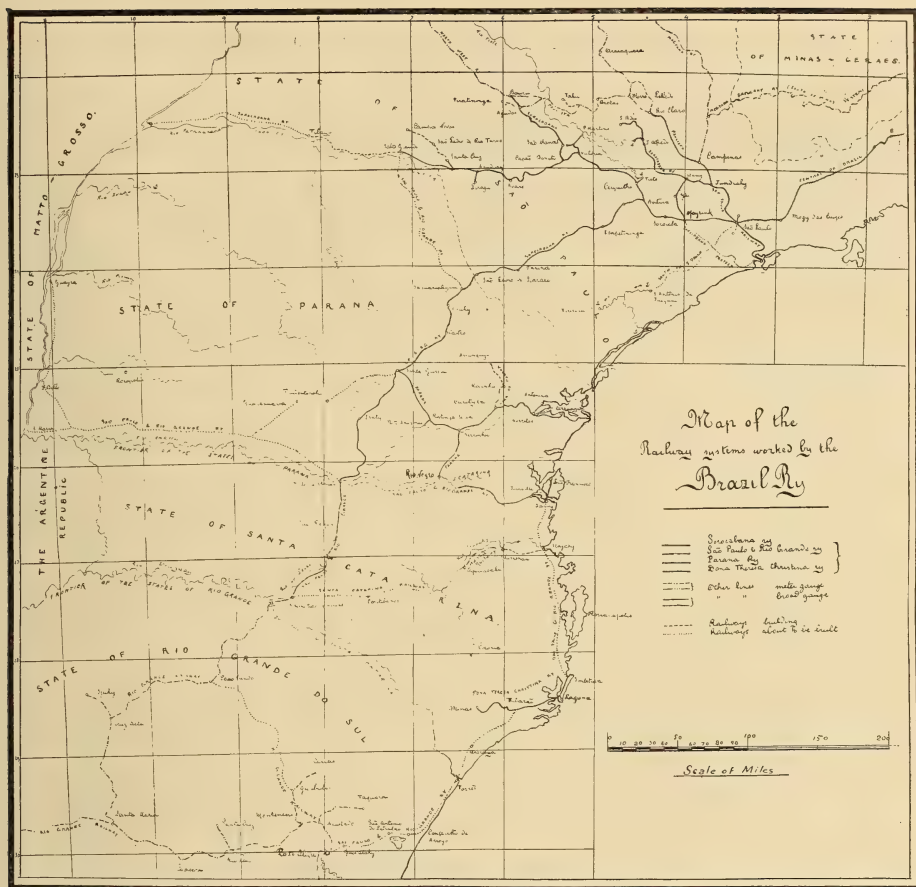
These various lines are all laid to the metre gauge.

There is a short line running northward from Curitiba to Rocinha, which is in operation, and was conceded to M. de Cerjat, who floated the North of Parana Railway, to work it.

The General Company of Brazilian Railways was bought up by the government, and the line was leased, until recently, to a private gentleman, Mr. Westerman, who was the representative of the State of Parana itself. The contract made between the Federal Government and the Brazil Railway Company in 1910 granted the latter the right of working the Parana Railway for the remainder of the thirty-year lease—that is, until December 13, 1934. The only immediate compensation to be received by the State was the reimbursement of the sums expended on rolling stock and on new works. The system has cost £3,500,000. The



TUNNEL AND VIADUCT ON THE PARANA BRANCH OF THE BRAZIL RAILWAY.



MAP OF THE RAILWAY SYSTEMS WORKED BY THE BRAZIL RAILWAY.

Brazilian Railway pays an annual rental equal to the maximum gross earnings since the line was leased to Mr. Westerman amounting to £148,500. Should the gross earnings reach £410,000, the company is to pay 20 per cent. additional of the net earnings above this sum.

It is provided that the charges shall be reduced so as to encourage agriculture, especially those rates which apply to lumber, cereals, maté and cattle, since these industries are already extensively developed. Maté, or "Herva Maté," is a plant of which a special kind of tea is made, this being drunk not only in Brazil but in the neighbouring Republics as well. It is also macerated in a

kind of bowl called a "cuia" and sucked through long stems, in the Indian fashion. The company carried no less than 44,000 tons of this tea in 1907, which, with the 6,000 tons carried by the Rio Grande and the Paraguay steamers, includes all the maté which was carried in the country.

The line is well operated, the cost being only 36 to 37 per cent. of the gross earnings, being the lowest in Brazil, notwithstanding the heavy gradients of the Serra. The fares, however, are among the highest in Brazil; but this is not altogether the fault of the company, as the portion of the government was formerly 50 per cent. of the earnings. The new

contract has changed all this, reducing the rental, as well as requiring a reduction in fares. This contract also contains a clause requiring the Brazil Railway Company to rebuild the Serrinha-Porto Amazonas branch, making it at least one-half shorter than it now is, and also easing the curves and gradients. The Serra section is stone-ballasted throughout, and is, therefore, less costly in working and maintenance than the rest of the line, although it gave much trouble at first.

The rainfall on the Serra zone is very heavy, and there are many landslides, causing considerable trouble. Thus, on one short section a portion, consisting of two tunnels and a bridge over a ravine, the bridge was carried away and the ravine dislocated, rendering it impossible to rebuild the line in the same place. The line was, therefore, relocated, involving the boring of a second and longer tunnel, and doing away with the necessity for the viaduct. In another case the mouth of a tunnel was continually becoming blocked up with soil until extensive works were completed to protect it against such obstruction.

A most curious incident is connected with the Presidente Carvalho viaduct, in itself a remarkable structure for getting around a corner.

A few years ago a fire broke out on the mountain side, resulting in the loosening and cracking of large blocks of stone, which began to fall, and threatened to carry away the railway line. Mr. von Bock, the superintendent of maintenance of way, covered the line with a rampart of heavy logs, some of them 3 feet in diameter, and in this manner the bridge was saved. The hillside was on fire for many days, and this is but one of the many instances in which it was necessary to devise special means for maintaining the traffic, which was interrupted but once for any length of time.

The rolling stock of the Parana system includes 22 locomotives, all

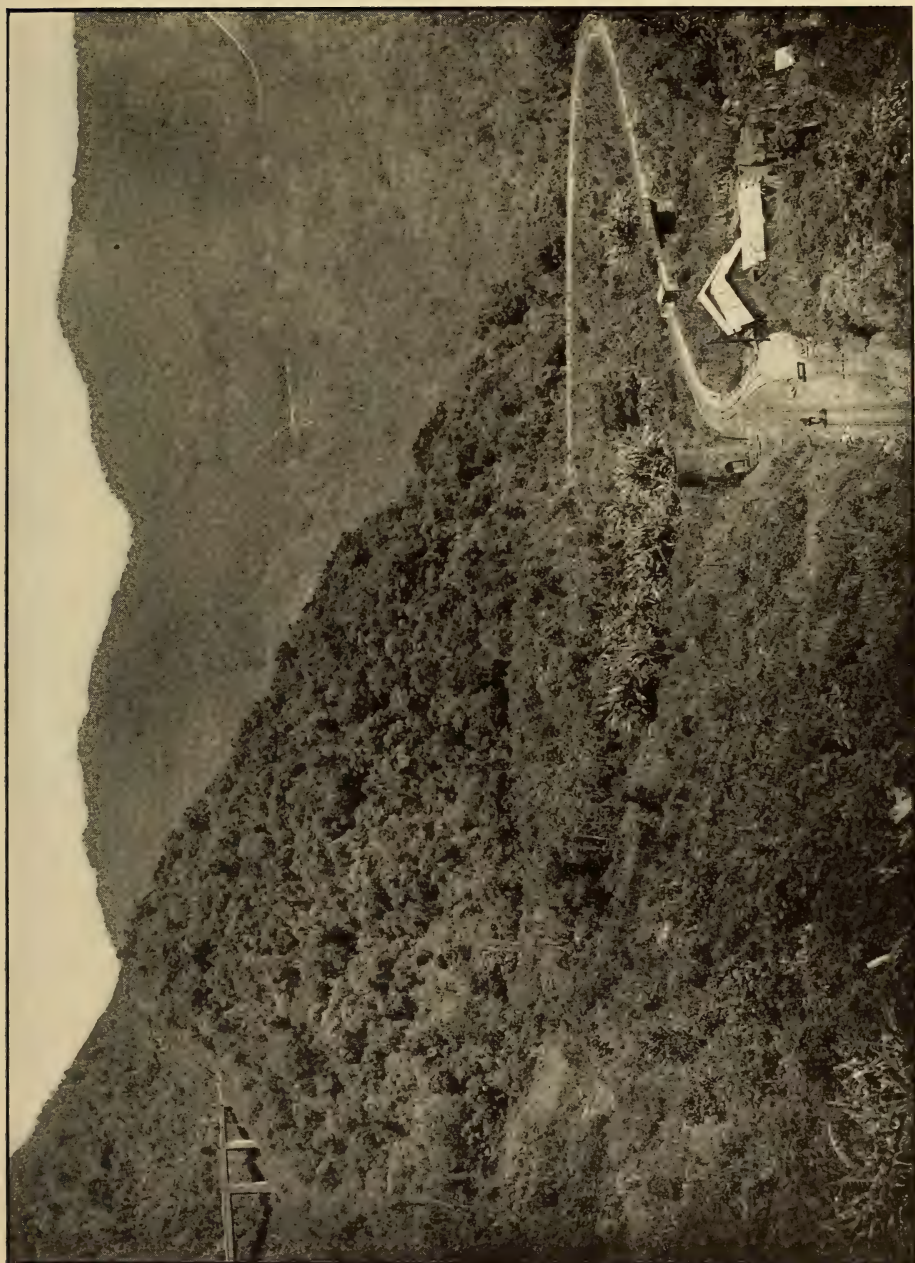
of American build, also 371 wagons and 41 coaches and vans, all of French manufacture.

THE SAO PAULO & RIO GRANDE RAILWAY

Although the States of Parana and Santa Catarina are two of the most healthful and productive in Brazil, their railway systems are still under construction. This is partly due to the fact that the original schemes were drawn up on too lavish a scale for the conditions of the time. From the outset there was planned a line running across both States from north to south, besides another, which was to extend from the coast all the way across to the Bolivian frontier. Another cause for the delays lay in political instability, due to the fact that a large portion of the territory which is considered as its own by Santa Catarina is in a state of litigation, being claimed by the State of Parana.

Notwithstanding these difficulties, the Sao Paulo & Rio Grande Railway, the outcome of an old scheme, is now nearly completed. The trunk line is the continuation of the Itararé line of the Sorocabana system, and passes through Castro and Ponta Grossa to Porto Uniao, on the frontier of Santa Catarina. The railway crosses the Iguassu river into Santa Catarina, and continues down the left bank of the Rio do Peixe to its mouth, at the point where the Rio Grande Railway meets it, on the Santa Catarina bank of the Upper Rio Uruguay. The total length is 655 miles, which are now nearly completed, the construction having given employment to about 7,500 men.

This line was originally conceded to a Belgian company called the "Chemins de Fer Sud Ouest Bresilien," the grant including a belt of timber land on either side and a branch westward to the mouth of the Iguassu. In the following year, however, the line was transferred to the Industrial Union for Railways in Brazil, the Sud Ouest Company re-



VIEW ON THE PARANA BRANCH OF THE BRAZIL RAILWAY

The Volta Grande Curve; the line shown at the bottom sweeps around the base of the hill, crosses the bridge at the left and is seen on the distant hills.

taining only the portions which lay in the State of Rio Grande. In 1894 the line was, in turn, handed over to the Sao Paulo & Rio Grande Railway Company.

The plan had always included an east and west line, the work having been carried on from the town of Sao Francisco, upon an island situated off the Santa Catarina coast. The channel is crossed on a dyke, provided with two swing bridges, and the line proceeds thence to Joinville and Sao Bento. It is now open as far as Hansa, a station situated at the sixty-sixth mile. It will probably enter the State of Parana at Rio Negro and follow the Iguassu river down its entire course until it reaches its confluence with the Parana river, and probably be continued still further.

On the opposite bank is the Republic of Paraguay, of which the government has conceded a line from this point to Asuncion, the capital, this being in the hands of a company called the Transparaguayan Railway. The writer is of the opinion that this line will be so modified as to start from Villa Rica, in the middle of the State, the rest of the road from Villa Rica and Asuncion being open to traffic. In this case the long eastern and western line may be useful, as it will form the shortest route from the Republic of Paraguay to the sea coast and would act to the advantage of the Sao Paulo & Rio Grande Railway in its competition with the Argentine Northeastern Railway.

Brazilian railway concessions are very elastic, and, as a matter of fact, the lines are usually conceded first and surveyed afterwards. It follows that the fact that the plan through Guarapuava has been sanctioned is a matter of no importance, and the route above described is the one which will probably be followed. Thus the line which was originally destined to reach Corumba now starts from Bauru, to which the origin has been transferred from



BRIDGE OVER THE RIO IGUASSU, SAO PAULO & RIO GRANDE R. R.

Uberaba. Again, the Goyaz Railway has been hesitating between two starting points—Araguary and Formiga—which are 300 miles apart, the same concession covering both; and, as a matter of fact, both lines are under construction.

Returning to the Sao Francisco extension, the portion between Sao Francisco and the main line was added as recently as 1902, at the time when the present company took over the system; whereas the western portion had been granted twelve years earlier. Both this Sao Francisco line and the Itararé, or southern line, have a gold guarantee of the government of 6 per cent.

In June, 1907, the Sao Paulo-Rio Grande Railway Company was conceded several more lines. These are four in number, viz.:

First, a branch from the Iguassu extension to Guarapuava.

Second, a branch from this same Iguassu extension to Salto de Sete Quedas, not far from the old town of Guayra. This is where the boundary between the Republic of Paraguay and that of the State of Matto

Grosso meets the Parana river. This branch would thus cross the river at a point where it is hardly navigable. In connection with this line the government decided, in 1910, to subsidize any company which would undertake to maintain a steamship service on the Parana river between Salto and Itapura, where it is crossed by the Northwestern Railway.

Third, there is a line which starts from Ponta Grossa, a most important centre, and runs westward to

portions have a 60-pound rail, with 16 sleepers to the rail; and on the Serra section of the Sao Francisco line, where it is intended to use heavy Mallet locomotives, 74-pound rails have been laid.

The longest bridge is that over the Iguassu river, which has three spans of 100 metres and five of 25 metres, and a total length of 1,400 feet. There was also some difficult work on the Sao Francisco line, including the Linguado bridge, and



BRIDGE OVER THE RIO YAPU EN CASTRO; SAO PAULO & RIO GRANDE RAILWAY.

Prudentopolis; this is really an inland extension of the Parana Railway.

Fourth, and last, is a line which starts from Jaguariahyva (on the northern line) and runs due north to Salto Grande, on the Paranapanema river, where it will join the new western extension of the Sorocabana system. It is understood that this line is to be constructed immediately, as it will run through some of the best grazing and coffee-growing land in Brazil.

The Sao Paulo & Rio Grande line has been pushed through quickly, being aided pecuniarily by the government of the Union. It is laid mostly with 46-pound rails, with 15 sleepers to each 33-foot rail. The newer

also the Piraty marshes, immediately beyond.

When the Sao Paulo & Rio Grande Company, as described, was turned over to the Brazil Railway, on March 31, 1910, the new contract decreed the formation of a system of railways in the States of Parana and Santa Catarina, to be entirely operated by the Brazil Railway Company. This system comprises the Sao Paulo & Rio Grande Railway, the Parana Railway, the Dona Thereza Christina Railway, besides a number of new lines which the company was required to build.

To these must be added the Sorocabana Railway, previously leased, the whole forming the Brazil Railway Company as it now stands. It

is a good grouping, and forms a real system, and not merely an amalgamation of lines, and serves a well-defined region which is sufficiently productive to remunerate an important railway undertaking. It also has the advantage of being free from the intrusion of any foreign railway, so that the Brazil Railway Company has entire liberty to organize its traffic as it sees fit. This traffic will be further developed by the three penetration lines: the Paraguay-Iguassu line in the south, the Paranapanema line of the Sorocabana system in the middle, and the Bolivia-Northwestern line in the north. These lines are sufficiently far apart not to interfere with each other in any way. They are connected with each other by the Parana river and railway, and inland by the Sao Paulo & Rio Grande Railway, but they do not have good connections with the coast. It will be necessary for the northernmost to be continued to Santos, which is the reason why the Brazil Railway wishes to build the Mayrink and Santos extension. The central lines will run down to the harbour of Paranagua, over the Parana Railway, and to Sao Francisco, when the new line is finished.

Further south there is no connection on the system; two lines run inward from the coast, but neither of them scales the hills, and one of them (the Hansa Gesellschaft) is still independent, the other, the Dona Thereza Christina Railway, having been turned over to the Brazil Railway by the government in 1910.

The line belonging to the Hansa Gesellschaft is the only German railway in Brazil. It is not a regular railway company, but is a colonizing one, having been found an essential adjunct to the colonizing plans of the company. The line follows the Itajahy river from its mouth to Blumenau and Aquidabahn. It is open to traffic only between these two towns, a distance of 28 miles, and the river is navigable for small craft from Blumenau to the sea, where

there is a small harbour of Itajahy. The company has begun the extension of the line to the coast, at a cost of £40,000. The line will also be continued inland, through Coritibanos to the mouth of the Rio de Peixe, where the Sao Paulo & Rio Grande Railway joins the Rio Grande system. It may even be continued along the banks of the Uruguay river all the way to the Argentine frontier.

The second road is much shorter, and is still known as the Dona Thereza Christina Railway. It runs from Laguna to Mina or Lauro Muller, 72 miles distant, where there are some coal mines. The coal is of inferior quality, and the railway has been operated at a loss, being 288 per cent. in 1908 and 334 per cent. in 1907. Now that it has been leased to the Brazil Railway Company, the government will pay one-third of the annual deficit during the first three years of the lease. The island in which Laguna is situated is connected with the coast by a bridge of 4,620 feet in length. The three longest bridges in Brazil, including the Rio Santa Maria bridge (longest in South America), are in this part of the country.

There is little doubt that there would be a brilliant future in store for either the Dona Thereza Christina Railway or the Hansa Railway if they could reach the inland plateau. Santa Catarina is especially a promising country, and its stunted development is attributed to lack of railway facilities, which are about to be provided by the Brazil Railway, and from which an interesting growth should follow.

It would be a difficult matter to get the Dona Thereza Christina Railway to the uplands, and it is doubtful if this is the best part of the State from which to start such a penetration line. The Brazil Railway has overcome this difficulty by joining the Dona Thereza Christina line to its own system, not through a penetration line, but by a seaboard



FERRYING A LOCOMOTIVE ON THE BRAZIL RAILWAY.

connection, linking the harbour of Sao Francisco with Porto Alegre, along the coast, and incidentally passing through the starting point of the Dona Thereza Christina line. This is one of the lines whose construction is specified in the 1910 contract, the company being given five years in which to build it. A guaranteed interest is attached to it.

It may seem strange that the company is not building the inland extension of the Dona Thereza Christina line. Such a line, however, would be longer than the new connection from Passo Fundo to Porto Alegre, now about to be built by the Rio Grande Railway. A large portion of this line is already open to traffic, and there would be no object in building an expensive alternative route.

The present Sao Paulo & Rio Grande Company was floated in 1902, in order to revive the old one and to pay off the existing liabilities, and it has already accomplished a great deal of good. The original

capital was only £1,000,000 in shares and £7,936,000 in debentures.

By the new contract the lines revert to the government after a period of ninety years, but to compensate for this the guaranteed capital has been increased. As an inducement toward the construction of this system the Sao Paulo & Rio Grande Railway has been granted six million acres of land, most of which is covered with forests of pine and hardwood.

In the development of railway enterprises in new countries there is a point which should be impressed, because it opens up new opportunities for success. A railway company is primarily one which owns and operates a railway, and in Brazil, as elsewhere, it must do all it can to foster the traffic to be carried by its line. Since, at first, there are no industries to provide the traffic, and because the railway people themselves know better than anyone else the possibilities of the district, both in character and location, it follows that the railway

itself must both create the traffic and go for it. It is only fair that the railway, which has borne the risk of opening up a line through an undeveloped district, should be the first to reap the profits derived from its enterprise. For these reasons a railway company in Brazil must not only operate the railway, but also endeavour to develop every possible industry in its own district. This point should be borne in mind by every railway enterprise. Thus, there are many districts in the southern portion of Brazil in which different kinds of ore have been found, but the country has not been prospected. This is not only a mistake in economics, but it is also a mistake from the railway point of view. It is, however, a mistake which is not being made by the Brazil Railway Company.

This company was granted a large tract of forest land, but it immediately started to buy more such land, paying an average price of 15 milreis per hectare. When it was believed that enough had been acquired to feed its lines and to export from all its harbours, the railway company started an affiliated company, called the Southern Brazil Railway Company. This company built a mill at Sao Roque, on the Rio do Peixe, with a capacity of 30,000 cubic feet per day, this to be followed by two others, much larger, capable of handling 200,000 feet each. This Sao Roque property covers 87,000 hectares (215,000 acres), and it is producing enough in sleepers for the railway to more than repay the company for its outlay.

The recent contracts require the railways to start colonizing operations along their lines, which is an excellent policy. The Brazil Railway has begun colonizing at Campo, near Ponta Grossa, and hopes to have about 2,000 hectares (5,000 acres) under wheat within a year. The land is divided up into sections and sold to immigrants or other purchasers at a price of 150 milreis (£4, or \$20, per acre) per hectare. The company

furnishes help at first for building houses, fencing the land, and supplying grain and implements, these advances being refunded in twelve half-yearly payments.

These two examples will illustrate the methods employed by the Brazil Railway in developing the country, and it will certainly have the goodwill of the government in such work.

In 1909 the receipts had already reached 2,200 milreis per kilometre, which is good for such a country.

The rolling stock of the Brazil Railway calls for little comment, as it is mostly built to order. An interesting point, however, and one which cannot be sufficiently commended, is the standardization of types which the railway is enforcing. It is remarkable that, while locomotives have been built for many years for several Brazilian railways, nearly all of them for the metre gauge and operating under similar conditions, no standards should have yet been reached. So far as locomotives are concerned, there are to be four principal types. These are: A mogul locomotive, such as are now used on the Madeira & Mamoré Railway; a 10-wheel engine, already used by both the Sorocabana and the Sao Paulo & Rio Grande sections; a consolidation locomotive, similar to those already supplied for the Madeira & Mamoré line; and the Mallet type, already described as built for the Sorocabana Railway.

These engines are believed to suffice for present needs, and additional types will be added as required. A Mallet engine, having an adhesive weight of 96 tons, is already under consideration.

We have already noticed the Madeira & Mamoré Railway,* and the first section of this line, from Santo to Jucy Parana, a distance of 54 miles, was opened in May, 1910, and the road will shortly be open as far as the station at Rio Muticury Parana, about 110 miles. Work is

* See CASSIER'S MAGAZINE, June, 1910.

being pushed rapidly on this line, and some temporary wooden bridges have been erected, although these cannot be expected to resist the attacks of the white ants for any length of time.

The longest bridge on this line is a pin-connected through truss of 280 feet span, with two lattice spans of 80 feet. The other bridges are deck lattice spans and plate girders. Concrete is used for masonry, as the available stone is unsuitable.

The difficulties which were for-

merly experienced in the construction of this road by reason of the unhealthful nature of the district are being overcome, and the railway has secured the services of Dr. Oswaldo Cruz, who did so much to free Rio from the yellow fever. Few lines have required a greater degree of perseverance to surmount the difficulties encountered in construction, and much credit should be given to the Brazil Railway Company for its determination and success in this important work.



DESIGN AND APPLICATION OF THE MODERN BALL BEARING

By J. F. Springer

In the February issue of this magazine, the first installment of the present article reviewed the conditions of sliding and rolling frictional resistance, and examined some of the fundamental principles involved in the correct design of ball races and groove profiles. The present installment continues the theoretical investigation, and this will be followed by illustrations and descriptions of some of the practical applications of the principles this developed.—EDITOR.

CONSIDER now the effect of rotation. Let the driver be the outer raceway. The point of contact of this raceway with the ball at position of maximum load is at its maximum distance from the center of raceway. Its linear speed is therefore at its highest. In accordance with a principle already given, the center of the ball is moving forward at one-half the linear speed of the driving point. So that at this moment the ball has its greatest velocity in its orbit. It will therefore crowd the ball ahead and draw away from the one behind. If the inner raceway is the driver, the reverse will be the result, because the greater the compression the slower the linear speed of the driving point. In either case, the ball under maximum load crowds a consecutive ball, either forward or behind. Taking all the foregoing considerations into account it would seem probable that conditions may easily be such that pressure does really exist between balls. To eliminate or minimize its frictional effect, separators may be used. These are of two general types—the rotating and the non-rotating. A ball or other round body may be introduced between bearing balls. By this means, the contrary movements are harmonized, as will be understood by consulting Fig. 7. What was before sliding friction has now been transformed into rolling friction. These separators must, however, not be driven. Ordinarily, they are of smaller diameter than the bearing balls. If they are balls, their centers must lie in the same plane as the centers of the bearing balls. Otherwise they will be forced in an axial

direction. Further—the center of such a separator ball must lie exactly on the line of centers of the adjacent bearing balls. See Fig. 8. It will be seen at once that should the three centers not be in the same line, the separator ball itself would be caught in a wedge, forcing it further in or out. Consequently, the separator ball itself would be rotating under pressure against some other part of the bearing.

From an inspection of Fig. 8, we derive the formulae,

$$x+r=R \sin \phi$$

$$y=R \cos \phi$$

If the circuit contains n bearing balls,

$$2 \phi = \frac{360^\circ}{n}$$

We have, then, for x and y ,

$$x=R \sin \left(\frac{180^\circ}{n} \right) - r$$

$$y=R \cos \left(\frac{180^\circ}{n} \right)$$

These enable us to determine the radius and pitch circle of the separator balls.

If we use a non-rotating separator, we do not eliminate sliding friction. We substitute two sliding contacts when the velocity of the slide is one-half that between contacting balls. Whether there is any considerable advantage in this may well be doubted. However, separators are sometimes employed for reasons other than the elimination of friction. In certain types of raceways, it would be impossible to assemble the bearing, if a full complement of balls were employed. Thus in one of the types of bearing known as annular,

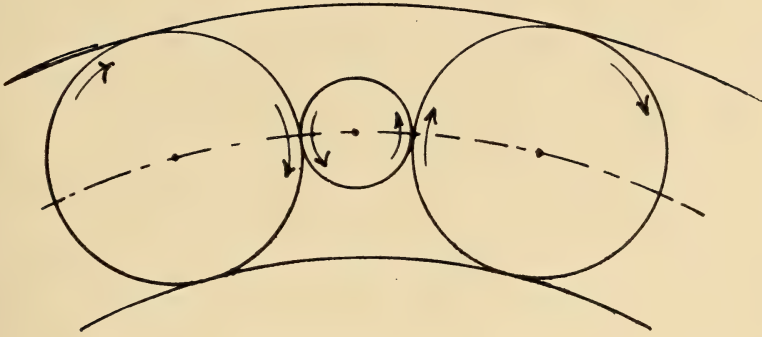


FIG. 7.—ACTION OF SEPARATOR BALL.

the balls occupy less than 180° of the circuit. The remaining space is taken up with separators or separators and circular clearance. Such bearings could be assembled with a full complement by using slots or a detachable piece. But such methods seem somewhat objectionable because of

the imperfection in one or both rings thus introduced. The use of large non-rotating separators may seem unwise to some because of the halving of the ball complement. But, if really one ball takes the great bulk of the load when the circuit is full, a slight increase in the size of ball

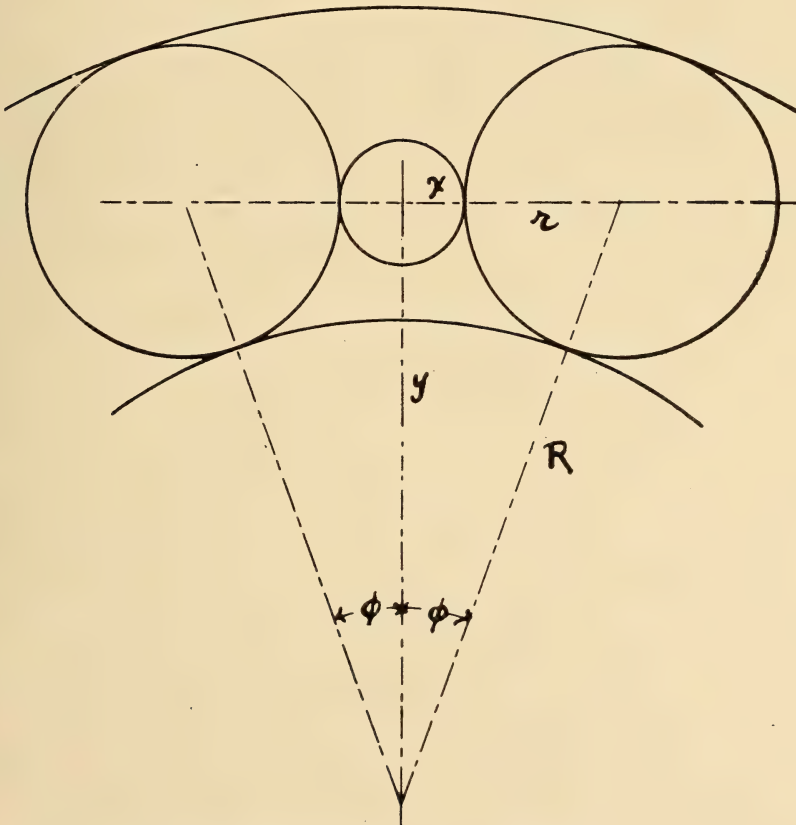


FIG. 8.—RELATIONS OF SEPARATOR AND BEARING BALLS.

used would no doubt offset this loss. Non-rotating separators may be divided into two classes—those with parallel faces and those with radial faces. When the faces are parallel, the thickness may be calculated in precisely the same way that the radius of x of the rotating separator was found. Only here the thickness will be $2x$. If the faces are radial, the angle may be ascertained simply by dividing the total angle of circular clearance left by the ball complement by the number of balls. It may seem desirable to allow clearance between balls and separators. Those who have followed what has already been set forth will have little or no difficulty in making such allowance.

To formulate the condition of a

$$.21875 = R_1 \sin \left(\frac{1296000'' - 4154''}{30} \right) = R_1 \sin 43062'' = R_1 \sin 11^\circ 57' 42'' = R_1 (.2072)$$

full complement of balls without circular clearance, recourse may be had to Fig. 8. Let $x = 0$. We then get,

$$r = R \sin \phi$$

Replacing ϕ by its value, $180^\circ / n$ we have

$$r = R \sin \left(\frac{180^\circ}{n} \right)$$

To introduce circular clearance, let k be the total amount in degrees. The condition will now be,

$$r_1 = R_1 \sin \left(\frac{360^\circ - k^\circ}{2n} \right)$$

It will be well to illustrate this matter by a numerical example. Suppose we wish to design a bearing with an external diameter of 3 inches and a hole of 1.375 inches. If we allow 0.750 inch for the four thicknesses of metal, we shall have 0.875 inch for double the diameter of the ball. We write then, $2r_1 = 0.4375$, ($= 7/16$). Allowing about 0.375 for double the thickness of the outer ring, we assume tentatively $R_1 = \frac{1}{2} (3 - .375 - .4375) = 1.09375$

The angular space, 2ϕ , occupied by a ball of radius 0.21875 whose center is at the distance of 1.09375 from the center of revolution is given by the equation

$$\sin \phi = \frac{.21875}{1.09375} = .2$$

$$\phi = 11^\circ 32' 20''$$

$$2\phi = 23^\circ 4' 40'' = 83080''$$

The whole circle contains 1296000''. Dividing by 2ϕ , we get 15 with a remainder of 4980''. As this remainder exceeds one-half the angle subtended by a ball, it may be thought well to reduce it. We assume $k = .4154''$ and proceed to determine the pitch circle radius (R_1) corresponding. We still retain $n = 15$.

From this we get,

$$R = 1.0557 \text{ inches.}$$

This is quite a little different from the value tentatively assumed, so it is necessary to see how it will leave the metal above and below the balls. Between balls and the hole will be $2 (1.0557) - .4375 - 1.3750 = .2305$

inch. If we are not satisfied with this disposition of metal, we can reduce the circular clearance somewhat, and thus permit an increase of thickness with the inner ring and an equal decrease for the outer ring. It is good practice to make the total circular clearance about 25 per cent. of the angle subtended by the ball. In the present case this would permit a considerable change in the pitch diameter.

It has been assumed in the foregoing that clearance in an axial direction is *nil*. In fact, this is precisely the manufacturing ideal. It cannot be fully attained commercially. It is surprising, however, how close the approximation really is. Balls are made whose error is no

more than 0.0001 inch. Raceways are ground with the same accuracy. Even so, all the errors may conspire in the direction of looseness radially or of tightness. The testing of radial clearance is accomplished by one of the principal manufacturers in an indirect but effective method. The two rings are displaced relatively to each other in an axial direction by a moderate pressure. The total axial clearance is disclosed in an exaggerated manner by this displacement. There will be exaggeration because the profiles of the raceways at the four points of contact closely approximate for some distance straight lines parallel with the axis. If the axial displacement is more than 0.006 inch, the radial clearance is deemed too great. If it is less, the radial fit is too tight. This might, perhaps, seem to some an ultra refinement without practical value. This is, however, not the case. It should be borne in mind that preferably a ball bearing for radial loads is mounted in such a way as to free it from an axial thrust. Generally the outer ring has a sucking or sliding fit in the housing. With anything but a most minute radial clearance, the shifting of this ring axially would present a line of contact whose distance from the shaft axis would undergo changes. An inequality of action would thus arise which, especially with heavy loads and high speeds, could hardly be objectionable. If the loosely-mounted ring is the driver, there is, perhaps, a more serious objection arising out of the varying speeds of the balls due to the changing linear velocities of the contact points of the ring.

The question of material is a very vital one. It is coming to be very generally recognized that tool steel should be used throughout. The case-hardening process is undoubtedly capable of producing an exterior film whose hardness and fineness of grain are entirely satisfactory. If the interior acted in precisely the same way as the exterior under deforming ac-

tion, then we might get satisfactory results. It would seem, however, that this is not the case. An experiment in this connection was tried where case-hardened balls were tested against alloy tool steel balls. The alloy balls were 9/16-inch diameter and the case-hardened ones 7/16-inch. The exterior diameters were about $3\frac{1}{2}$ inches and the holes 1 9/16 inches. While the one bearing had balls $\frac{1}{8}$ inch less in diameter than the other, the rated capacities were the same. I think that doubt is justly to be entertained as to whether a bearing containing more 7/16-inch balls is fully the equal of one containing a less number of 9/16-inch balls. However this may be, the two were tested to destruction without lubricant. The load was 4000 pounds and the speed 325 revolutions per minute. The tool steel balls survived for 48 hours, the others for 10 hours. The case-hardened portions shelled badly. In some cases, nearly the whole of a hemispherical shell came loose from the interior in a single piece. This phenomenon emphasizes pretty clearly the difference in behaviour of the hard and soft parts.

In hardening the balls and raceways, it is deemed well to bring all to the same degree of hardness. On the Shore scleroscope scale this degree is about 80 to 85. The balls must be hard to resist deformation. This imposes hardness upon the raceways as otherwise the sharp curvature of the ball would excessively deform and wear the raceways. Further, the same steel should be used throughout, according to one of the prominent makers.

It is an important matter to ascertain the loads actually endured by a ball to which a given load is delivered. Consider Fig. 9. The vertical load received by the outer ring is transformed into stresses normal to the contacting surfaces and so passing through the ball center, where they may be regarded as reconverted into the original vertical

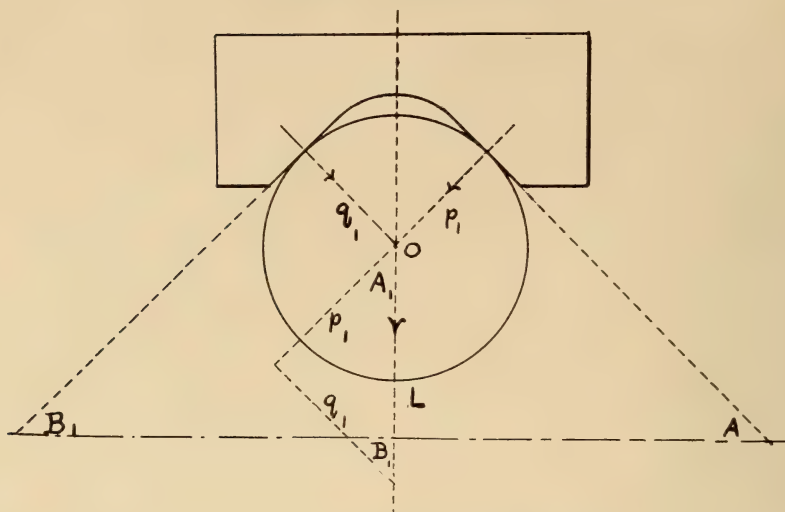


FIG. 9.—LOAD DISTRIBUTION ON BEARING BALL.

load. We have, observing the figure,

$$p_1 \cos A_1 + q_1 \cos B_1 = L$$

Similarly, we may obtain for the inner groove,

$$p_2 \cos A_2 + q_2 \cos B_2 = L$$

We have, in addition,

equal to 71 per cent. of the load. Apparently this is an advantageous disposition of the load, even though four points are involved. But the reduction of 29° of the crushing stress is much more than offset by the large 45° angle between raceway

$$\begin{aligned} \frac{p_1}{q_1} &= \frac{\sin B_1}{\sin A_1}, \text{ or } p_1 \sin A_1 - q_1 \sin B_1 = 0 \\ \frac{p_2}{q_2} &= \frac{\sin B_2}{\sin A_2}, \text{ or } p_2 \sin A_2 - q_2 \sin B_2 = 0 \end{aligned}$$

These equations give us,

$$\begin{aligned} p_1 &= \frac{L \sin B_1}{\sin (A_1 + B_1)} = \frac{L \sin B_1}{\sin C_1} \\ q_1 &= \frac{L \sin A_1}{\sin (A_1 + B_1)} = \frac{L \sin A_1}{\sin C_1} \\ p_2 &= \frac{L \sin B_2}{\sin (A_2 + B_2)} = \frac{L \sin B_2}{\sin C_2} \\ q_2 &= \frac{L \sin A_2}{\sin (A_2 + B_2)} = \frac{L \sin A_2}{\sin C_2} \end{aligned}$$

where C denotes the angle between the profiles of a groove.

Bearings have been made where the angles A and B were all 45° . The normal pressures at all points of contact would be the same and

profile and instantaneous axis. The inevitable pinch would develop enormous friction under heavy loads. It is much better to use small angular values for A and B and thus secure a decrease of the normal loads.

For the values $A_1 = 7\frac{1}{2}^\circ$ and $B_1 = 12\frac{1}{2}^\circ$, for example we get,

$$p_1 = \frac{L \sin 12\frac{1}{2}^\circ}{\sin 20^\circ} = \frac{2164}{3420} L = 63\% (L)$$

$$q_1 = \frac{L \sin 7\frac{1}{2}^\circ}{\sin 20^\circ} = \frac{1305}{3420} L = 38\% (L)$$

Let it be observed that the total load has been only negligibly increased, and that for these small angles, the distribution is approximately in an inverse ratio to them. That is,

$p_1 : q_1 = B_1 : A_1$ (approximately). Thus if we make A_1 and B_1 , each equal to 10° , we shall obtain an equal division of the load. Instead of the whole being carried at a single point of contact, it will be evenly divided between two. In both of the last two examples the value of θ_1 is small, 10° , so that the friction from compression will be but slight.

If one raceway presents but a single surface, the formula for the normal pressure may be obtained by regarding $B_1 = 90^\circ$ and thus eliminating the corresponding surface from delivery of the vertical load. We then get

$$p_1 = \frac{L \sin 90^\circ}{\sin (A_1 + 90^\circ)} = \frac{L}{\cos A_1}$$

This formula shows, since the $\cos A_1$ is always less than unity, that the pressure on the ball is increased by inclining the raceway profile to the shaft axis. However, with quite small angles the cosine is so near unity that for them the increase is negligible. Thus for a small angle as large as 14° , with a cosine of .9703, the increase of the normal pressure over the vertical load is but 3 per cent. For small angles then, the inclination of the single surface profile should have little or no influence upon design. That is, there should be none from the point of view of pressure. The value of the angle θ is another consideration and should never be allowed to drop from view.

For two-point contact, we have two single-face profiles instead of

one. These must be parallel. Consequently, the normal pressures will both be the same.

In many bearings, curved profiles are employed. The foregoing formulæ, of course, apply when we conceive the curves replaced by tangents at the contact points.

When we consider the matter of contact, it is not difficult to see that the *form* of the raceways plays an important rôle. Viewed transversely, we have on the side of the outer raceway a small convexity contacting with a larger concavity. On the side of the inner raceway, we have two convexities. The ball is, in the latter case, very inadequately supported. There is here, no doubt, a decided tendency to flake off, which is only to be met adequately by a proper choice and treatment of material. Other things being equal, the ball will be more damaged by the inner raceway than by the outer. Further, the inner raceway itself is subject to the same tendency to flake, although no doubt to a less extent. If it is true that nearly the whole of the load is carried by a single ball, then it would seem that some relief from the damage of convex-to-concave contact would result from using as large balls and inner raceway as possible. If the inner raceway turns and the outer one remains quiescent, there is an equalization because of the distribution of wear over the whole of the one. But, if these conditions are reversed, then the distribution occurs where there is less need for it, so that in such cases we may expect the inner ring to have much the shorter life. The foregoing considerations apply to all descriptions of bearings, appearing to

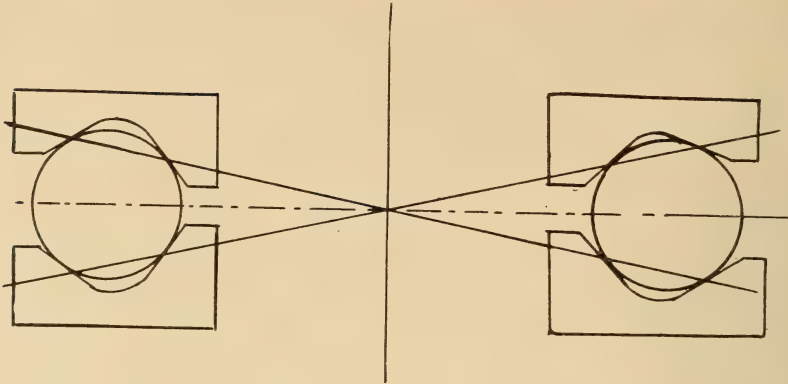


FIG. 10.—FOUR-POINT THRUST BEARING.

be necessary conditions. But when we pass an axial plane through a point of contact we find that different styles of bearings disclose different characteristics of contact. No approved design known to the writer, however, exhibits a convex-to-concave contact. The profiles are straight or concave.

In certain recent types of two-point bearings where both points lie on the same shaft radius, a circular profile is employed whose radius of curvature is but little greater than that of the ball itself. The result is a hugging contact affording excellent support to the ball. When deformation takes place under load a considerable area is involved. But because of the positions of the contacts, the angle θ remains small throughout the contact region. Consequently, friction is kept down as well as resistance afforded to flaking. After severe and long continued experience, this type has proved itself as possessing high wearing quality.

As to straight profiles. There is no doubt that with the same pressures the type of contact here afforded is inferior to the concavo-convex. However, it may be questioned whether the inferiority is considerable. If, indeed, the loss in closeness of contact is not great, we may, at times, desire to use the straight profile, expecting to gain elsewhere what is lost in one respect. As has

already been pointed out, a raceway presenting two profiles to the ball with the angle θ small affords opportunity to divide the load.

In the discussion so far, the type of bearing in mind has been largely that which receives its load radially. There is another important class—the thrust bearing. In Fig. 10 is represented in axial section a typical four-point thrust bearing. In large part, the laws are the same. But there are important points of demarkation. It is almost inevitable that the instantaneous axes should intersect on the shaft axis in the neighborhood of the bearing. In consequence, it also seems inevitable that one or more profiles should make a considerable angle with the corresponding instantaneous axis. It is possible, however, to make this angle small for the profiles of one groove. By using a single profile in the other raceway, instead of two, the corresponding angle there may also be kept small. And so also, if single profiles be used in both raceways. If hugging curves be used, however, in the two-point form, the area of contact will be so considerable that there will surely be a tendency to establish impossible parallel instantaneous axes. This would seem to be an item against close circular grooves. However, the superior support of the ball is an item on the other side of the account.

(To be concluded.)

THE CONVENIENCE OF THE PUBLIC

By Charles D. Seeberger

Many years ago the accepted definition of engineering as the "art of directing the great sources of power in Nature to the use and convenience of man" was formulated by Tredgold, and its application has been the aim and endeavour of the leaders of the profession ever since. Under such circumstances, it becomes desirable to call attention to the extent to which this fundamental principle is sometimes violated, and to point out conspicuous examples of the loss to the community which follows the enforced inconvenience of man. Unfortunately, there are many such examples, and in the following article Mr. Seeberger notes but one among several which might be used to point his argument.—THE EDITOR.

THE man intrusted with designing and building a project of unusual magnitude is apt to be impressed, and becomes more so as time goes by, with the great labour and infinite detail involved. It would not be surprising if, in drawing the mental picture of the undertaking, his perspective be faulty, due to taking his "point of view" or "station point" too close to the "picture plane," resulting in his foreground becoming the distorted picture, accurately drawn though it be, and the background insignificant. It is possible that another, untrammelled with responsibility for the labour and the detail, having the leisure to walk around the "subject," might select a "station point" from which a picture can be drawn embracing all the elements in their real relation and in true perspective. It is even possible that the background of the first picture may prove to have the elements which will make the foreground of the second picture, because all elements are not of equal importance, and those involving labour and detail may be of very minor value, consequently not suited for the foreground. If there is one element or factor of the problem of overshadowing importance it ought to dominate the picture.

If we marshal all the factors involved in building a new railroad terminal, are we apt to find one even approaching the magnitude of this—"Convenience of the public"? The

railroad would not be built, nor could it exist, without the public; it receives its remuneration solely according to the degree it serves the public. If it pushes its tunnels under the river, and builds a terminal, at vast expense, it expects to be remunerated, and it will be, according to the public's estimate of the value of the convenience.

The remuneration comes from that portion of the public which has a choice and can select the service most to its convenience; but it does not follow that the convenience of the other part of the public, which must perforce accept the service, can be neglected, because it can reward or penalize in a medium other than cash fares—good-will.

Let us examine a notable project recently completed in America to see whether the picture in the mind of the designer was drawn from a "station point" affording a true perspective, in which the elements are properly grouped in the order of their importance, with the dominant "Public's Convenience" in the foreground and the mere details of construction in the background.

The project to which we have reference is the new terminal station of the Pennsylvania Railroad in New York City, a work which, by reason of its magnitude and importance, as well as its bearing upon the future development of the city, rightly claims attention in all its bearings.

The nearer the station is located

to the centre of the traveling public the greater its convenience. We can get an idea, from the existing transit facilities, in themselves the result of demand for public convenience, in what portion of the city the centre of the traveling public may be found.

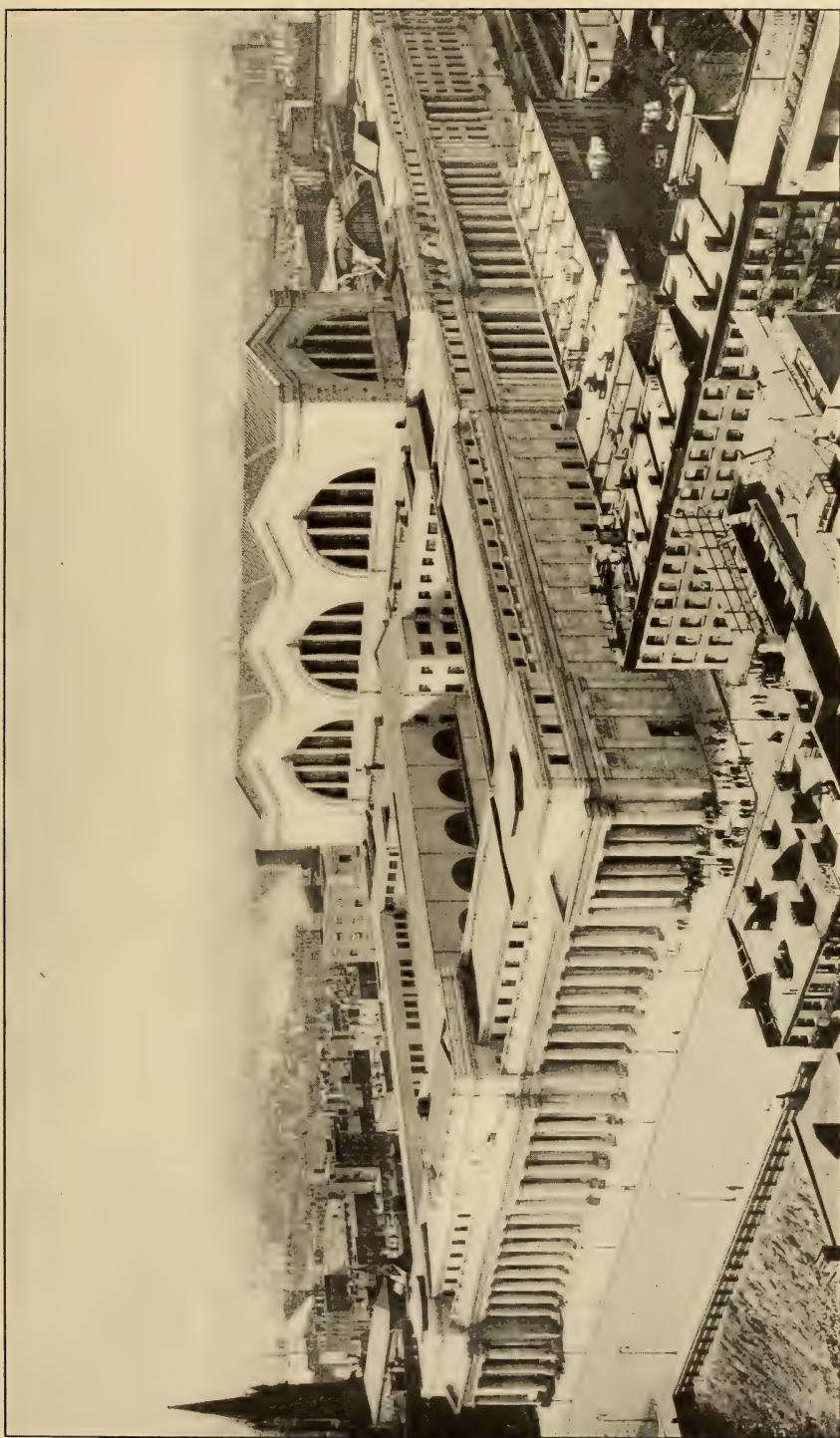
Endeavouring to find the location of this centre, or origin of traffic, in New York with reference to its east or west position, is attended with some difficulty, but there is none in considering the north or south, for we know that if we happen to fix on a centre north of its true position to-day it is only a matter of a few years until the northward growth has carried it even beyond this point. In fact, we are not particularly concerned with the condition of to-day, for the station was not built for a day. The hotel centre is somewhere about Fiftieth street, in the vicinity of Fifth avenue. Thirty-fourth street is the most prominent cross street, the next is Forty-second street, and the average location of rapid transit facilities is east of Broadway. Are we, then, not right in saying the Pennsylvania site is southwest of the centre? The site selected was in a section of the city where the transit facilities were but sufficient for the local needs. Did the designer lose sight of the public's convenience and rely too much on the hope the transit facilities might be changed? Why should he expect them to be changed except for the public's convenience, the very object of his picture? Or, granting for a moment that he was right in expecting public co-operation in this matter, how can he hope for a complete service without inconvenience, and delay of transfers, from a fraction of a line of subway, which may be diverted from a better location, because the city cannot afford to build both at present? Ought not the site of his picture to have been on Sixth avenue, with its elevated, surface and tube service, an artery in the transportation system? The additional cost of the land, most of which was subsequently acquired by the

Hudson tubes at a cost not regarded as prohibitory, would be a small item compared to the cost of building a subway system to provide the public's convenience at his station. The designer cannot now be heard to argue that the city should do thus and so, for he himself undertook to serve the convenience, with the result that he has immensely complicated the city traffic problem.

If we are right in placing the centre of traveling public at a point northeast of the station, then it follows that the public reaches the station traveling in a southwesterly direction, and impinges, so to speak, on the station at Thirty-third street and Seventh avenue. Instead of a portal welcoming entrance within, we find a driveway for vehicles, and we proceed another block south to Thirty-second street, where we are ushered into a corridor, which we follow for a distance of more than two ordinary city blocks to the concourse, with its doors opening on Eighth avenue, before we find the stairs leading to the track platforms, on which we must retrace our steps to the easterly, because the centre of the track platform is well to the east of the stairs.

The designer may have made a mistake in the site, as above pointed out; but this question as to the building itself, raises a query whether the designer has taken his "station point" so as to bring the "Public's Convenience" into the foreground as the dominating element. It is just possible that his preconceived idea of a station was a vaulted roof at great height over the waiting room, and this could only be accommodated to the architectural details of his façade by placing it on the minor axis of the building at a distance remote from the street.* If this hypothesis is correct, it is unfortunate that an inordinate ceiling height has become an apparent necessity in station designing, for really the passenger

* The pamphlet issued by the company refers to this as the "Station Proper."



THE NEW TERMINAL STATION OF THE PENNSYLVANIA RAILROAD IN NEW YORK CITY

cares very little for it. Had the designer shifted, slightly, his "point of view," he could have made his picture with the vaulted roof subordinated to Public Convenience by locating the waiting-room concourse on the Seventh avenue front, preserving his present façade, if he could be content with a 60-foot ceiling, or by selecting some other architectural monument for reproduction in his façade, if he feels he must have the 150-foot ceiling.

With the concourse waiting-room at Seventh avenue, the passenger would enter the building at his greatest convenience, for he could proceed at once to his objective—the train—eliminating a walk several ordinary blocks in length. If there be any really new factor in designing the building which cannot be dealt with in the customary way by copying from existing examples, it lies in the fact that the tracks are at an unusual depth below the level. Let us see whether the designer lost sight of his most important factor—"Public's Convenience"—in dealing with it. As we enter the corridor we find the floor is not level, but is pitched at a $2\frac{1}{2}$ per cent. grade. At about a block from the entrance it is interrupted by a short flight of steps, and a little further along by another and more serious flight. By this combination of incline and stairs we find ourselves about as much below as an ordinary elevated road station is above the street. The balance of the journey to the train is made by stairways.

The designer offers this as the solution of a problem involving a depth one-third greater than that at which the Public Service Commission, as guardians of the public's convenience, would make it obligatory on him to provide elevators were he designing a subway station. Much may be said in argument that a physician sometimes divides or disguises a dose in order to conceal facts from the patient. Perhaps it may be answered that the public is

not in position of a patient, and even if it were the question might still remain whether the physician had not made a mistake in giving a dose at all.

The sum total of exertion which must be put forth by the public on the stair facilities in the station as it is, or as it might have been with the stairs placed fairly, squarely and without disguise at Seventh avenue, is precisely the same. We find some provision for the sick and infirm, which, so far as it goes, is commendable as recognizing a care for this part of the public. If you ask the attendant, he will show you on each train platform an invalid elevator, upon which a wheeled chair may be elevated to the mezzanine floor, thence wheeled to either the Thirty-first or Thirty-third street end, where another elevator will lift it to the concourse level—in all, about one-half the distance to the street level. The bed-ridden may take an ambulance at the concourse level, while for those who are simply incapacitated for stair-climbing it remains for the porters to carry the chair and occupant up the stairs, 20-odd feet, to the street level. It is, perhaps, fortunate that the number of bed-ridden among the passengers is small. There is, of course, a large class of invalids; unfortunately, a very large one—those with organic troubles, threatened with heart failure, apoplexy, and the like—not to speak of large numbers of women to whom this invalid elevator provision does not readily lend itself. Perhaps the designer here lost sight, in a measure, of the Public's Convenience in thinking of the public as almost altogether of the young and alert. In placing his waiting-room concourse below the street level, the result of disguising the dose, did the designer have in mind that there was a certain percentage of the daily use of the station by the public other than for the purpose of taking trains? We refer to those going there to meet friends, or to make

inquiries and reservations. Was the convenience of this class considered in placing the waiting-room so far below instead of upon the street level?"

If the public avails itself of the services of the restaurant, fruit stand, barber shop or lavatory, it involves a flight of stairs in each instance, because they are situated on a different level each from the other and from the waiting-room, as an incident of dividing and disguising the dose—that is to say, in the attempt to conceal the excessive depth to the tracks below.* Merely to say that, as built, the station involves a couple of ordinary block-lengths of needless walking between the Seventh avenue entrance and the stairs to the trains at the Eighth avenue front carries little to the average mind, for to the young it is a matter of indifference, to the middle-aged one of concern, and to the aged and infirm it is almost prohibitive. Let us put it collectively, considering the public as a unit, and we can see what a couple of needless blocks means to a unit composed of 100,000 passengers in a day: $100,000 \times 2 = 200,000$ blocks, averaging 20 to the mile. Now, dividing 200,000 by 20 gives us *ten thousand miles* as the distance one man would have to walk if he undertook to do all this needless walking for himself and his fellow passengers; but as it is even difficult to grasp this magnitude, suppose we delegate 500 men to walk 20 miles each per day.

Elevators might have been employed to relieve the public of the stair effort. In fairness to the designer, we will admit that no trans-continental railroad station exists wherein elevators are provided to handle the entire traffic, and, consequently, the designer had no example to draw from; for, of course, the fact that the entire traffic of the London

Underground roads is handled by elevators, as is also the case at certain subway stations in New York City, notably at 168th street and 181st street, is hardly an example to be followed, for these roads are operated entirely by electricity, do not employ locomotives outside the city, their mileage is short, etc. True, we cannot quite comprehend the relevancy of these facts, and in them merely recognize a peculiar attribute of the human mind—a fear of one's own judgment unsupported by that of others. It is this attribute which produces the "practical man"; for, according to Disraeli, he is one who practices the blunders of his predecessors.

It will be interesting to see how much energy per day the public expends upon the staircases. It is near enough for purposes of illustration if we assume the total rise from trains to surface is equal to two staircases. With our assumed 100,000 passengers per day as before, we find they ascend 200,000 staircases. This conveys nothing to the mind, so let us reduce this also to comprehensible terms. The amount of stored energy which a labourer usually expends during a day's work is known in a general way. Of course, there is a difference in the physical conditions of the men, and the amount of stored energy varies accordingly. Let us assume the traveling public is of about the same stamina as the operatives of a textile mill, because it will simplify the problem, inasmuch as it has been estimated that the energy consumed by the operative in a day's work is equivalent to that required in climbing 200 flights of stairs. It is the recognition of this fact which has led certain mills to provide elevating apparatus for the employees, with known beneficial results. Assuming, then, 200 flights of stairs is the equivalent of a day's work, we have, dividing 200,000 by 200, a quotient representing 1,000 people working one day each.

This gives us a grand total of energy needlessly expended equivalent

* The official pamphlet states this more euphony as: "The tracks are located at a depth below the street level sufficient for the passage of trains under the buildings of the city, yet the descent to them, and the ascent to the streets, through three levels is scarcely noticeable"

to that ordinarily expended by 1,500 people in a day's work, and as 1,500 is $1\frac{1}{2}$ per cent. of the assumed 100,000 passengers, it follows that each individual needlessly expends in the station $1\frac{1}{2}$ per cent. of the energy otherwise allotted to his daily business. In this we have assumed each has the average amount of stored energy, which, of course, is not the case, for the average lies between the very strong and the very weak. The former will not be conscious of the wasted effort, while among the latter will be some not having $1\frac{1}{2}$ per cent. of the average stored energy; some of these will die in the station, more in their homes as an after-effect. Wasted time is the corollary of wasted energy.

If convenience of the public means

anything, it means conservation of its energy and time, and to the extent energy and time are wasted to that extent the public is inconvenienced. We began this investigation with the assumption that the station was built solely for the public's convenience, and that it should have been the predominant factor and in the foreground of the designer's mental picture of the completed station. If we are correct in this hypothesis, are we also correct in concluding that the designer was in error in selecting his "view point" from which he drew the picture, and that his foreground is occupied by the myriad details and aggregations of material and labour, making a pleasing and well-drawn picture—the apotheosis of vastness?

DIAGNOSING AN INDUSTRIAL DISEASE

By H. F. J. Porter

II.—STUDYING TENDENCIES

TENDENCIES are cumulative, and, therefore, prophetic. If we should plot our experiences on a chart and draw a line through them, we would be able to observe the direction in which our course is heading, and could then exert our efforts intelligently to modify or continue it, according to our judgment. This is what the mariner does, and he never takes his hand off the tiller.

On land, however, we allow anybody to hitch his horse or his elephant or his steam engine to our industrial chariot, and then when we make no effort to control its movements and find that it is pulled in every direction we bemoan the sorry effect of the resultant of the applied forces. For it never stays in the middle of the road, and is constantly demanding our energies to extricate it from the ditches which run on either side, or to repair damages caused by its striking boulders or ruts which we have not taken the precaution to remove, even when we knew we could not avoid them.

However, we must not fall into a pessimistic state of mind over existing conditions. We have only to look about us to realize that, even with the haphazard methods which we have utilized, things are steadily improving. It is what we have experienced, not what may be, that affects us unfavourably, only we must improve our methods of utilizing our experiences to our future advantage.

Many of the forces which have been misdirected through ignorance are now being brought under control; but this control could be more quickly

and more intelligently obtained if we would only realize that conditions are results, not causes, and that to change them we must study them, in order to devise ways and means to do so.

When, 650 years before Christ, things got so bad in Jerusalem that he could no longer control them, Isaiah asked his chief men to meet him, saying, "Come and let us reason together"; and just as this means proved satisfactory then in obtaining results so it has continued to do so ever since wherever it has been applied.

We have seen how independent industrial establishments, totally unrestricted, have been allowed to enter the city and carry on their operations without regard to their effect upon the community in general and their neighbours in particular. It has been shown how these unrestricted operations, especially in the case of such highly seasonal-fluctuating industries as those devoted to the manufacture of clothing, have brought about and intensified all the social evils that exist here, and that, so far, the State, the city and the borough have taken no steps towards coming together to reason about changing the conditions that exist. But a movement has been started in this direction, at the instance of the people composing the Fifth Avenue Association, a voluntary organization of patriotic and cultured citizens, who take an interest in their surroundings and want to see their city the finest in the world and their streets the most beautiful that can be built.

This association has been plotting

a curve to ascertain the tendencies of the times, and, having traced some of them, it is now directing the attention of the authorities towards encouraging those which may be of benefit and towards restricting those which may be injurious, and they ask that those forces which are contributory in causing these tendencies be controlled, that they may be exerted towards the betterment of the industrial interests of the city in general and of those located upon Fifth avenue in particular in order that the latter may become a model for all other streets in the city to emulate.

It has been previously stated that, in the settlement of the strike of the cloakmakers last fall, a number of joint committees were formed, composed of representatives of the Employers' Association and the Employees' Unions, and that through these committees an avenue of approach was opened whereby the cloakmakers' industry of some 2,000 manufacturing concerns located in loft buildings in the middle zone of the city could be reached. The centralization of the administration of certain affairs of this industry is only one evidence of a tendency toward a type of industrial collectivism which is now taking place generally in industry. There are certain influences at work which are bringing about these conditions, notably the movement among labour organizations to affiliate by industries.

Industrial unionism, or the affiliation of the unions of all the crafts in a joint board of control, by which, in case of a strike, a whole industry can be shut down, is so much more formidable a weapon than the independent craft unionism that has been general, and which can affect only one craft in an industry at a time, that in self-defense employers in the same industry will have to similarly organize, and are now doing so, in order to establish an equal war footing.

But the tremendous inefficiency which is attendant upon having every

industrial "house divided against itself" is already becoming so apparent to the houses themselves that efforts to come and reason together on the part of the most enlightened are being instituted, the necessity being borne home generally by a serious strike.

This tendency has become evident by the fact that all the recent strikes have culminated in the establishment of joint committees, on which are represented the employer and the employee, and, through them, co-operation gradually replaces antagonism. These conditions were brought to the attention of the Fifth Avenue Association at one of the conferences, referred to previously, by the representative of the Mayor's Commission on Congestion, to which latter a proposition had been made to relieve the city of the serious congestion in the tenement districts and the various evils attendant upon the methods of operation adopted by these seasonal industries by removing them bodily from the city to a neighbouring suburb.

As has been pointed out, a tendency towards such a removal has already been indicated by the building of factories on Long Island, but it is going on in the usual undirected way. The proposition to the Commission on Congestion comprised a well-formulated plan of carrying out a constructive movement which could be repeated with one industry after another as often as it would become desirable.

As this plan contemplated making a beginning with the cloakmakers' industry, it, of course, interested the Fifth Avenue Association; for if that industry should be removed from the city the street-loitering problem would be solved, at least temporarily. This plan proposed starting with a shaping up of this industry along the lines which Mr. Louis D. Brandeis, who had been instrumental in the settlement of its recent strike, had advocated before the Interstate Commerce Commission

at its recent hearing in Washington on the proposed advances of the railroads in freight rates—viz., that the principles of scientific business management should be adopted by the railroads for the purpose of conserving the wastes in labour and materials which were taking place in their methods of operation.

The Fifth Avenue Association realized that, if this proposition could be carried out, not only would the congestion of its street be brought under immediate control, but that the future development of its growth and the improvement and beautifying of its architectural features could be directed by the city instead of being allowed to develop by haphazard methods, uncontrolled, as at present.

In order to understand this proposition, it will be interesting to review it briefly, as follows: It was suggested that the joint committees already formed be housed in a building of considerable size, of which there were several available on Union square, which location would be fairly central to the industry, and that they should develop there a Cloakmakers' Board of Trade to administer such of the general affairs of the industry which do not encroach upon the autonomy of each manufacturing establishment. The officers of this Board of Trade should be paid good salaries in return for the economies and benefits that would accrue to the industry. For instance, it was proposed that there would be an employment bureau established, with an inspector to examine physically and investigate the credentials of every applicant for work, and only those who were fit would be accepted, those who were unfit being referred to the proper city departments or local civic organizations already organized for the purpose. The successful applicants for positions would receive slips printed in their various languages and in English, and lantern-slide talks would be given to them while waiting for employment, instructing them what the

standard conditions should be, both in the tenement and in the factory, and they would be told to report to the sanitary committee of the Board of Trade regarding the conditions as they found them if they were not up to those standards. Thus both the remiss landlord and employer would be discovered and dealt with. Landlords and employers would be furnished with cards for posting in the tenements and factories, respectively, calling attention to the sanitary conditions established by the Board of Trade and installed accordingly, and calling upon the employees to maintain them. Workers would not be sent to objectionable employers, or vice versa, nor to factories or homes which were not up to standard. Flat and loft-renting bureaus would be established to bring into better relationship the locations of shops and employees, so that employees would, where possible, be assigned to work in shops near their homes.

At present there are employees living in Brooklyn who work in factories on the West Side of New York, and others who live in New Jersey who work in factories on the East Side of New York. Owing to the inadequate and congested transportation facilities, these people have to rise from 5 to 5:30 o'clock in the morning to get their breakfast and reach the factory building at 7:30, and then they find the elevator service so restricted that it takes half an hour to get upstairs when the building contains from 1,000 to 2,000 employees. If an employee is late, some of the manufacturers do not admit him until noon, so that half a day is lost.

For each employee who would contribute one week's wages in instalments to a fund as an indemnity in case of leaving his work without giving one week's notice, each employer would contribute the same amount as indemnity in case of the discharge of the employee without a similar notice. This employment guarantee or insurance fund, if only half of the

employees would contribute to it, would amount to nearly \$250,000, the interest on which would supply sickness and accident relief and disability pensions to participants. It would be kept in a co-operative bank and invested in the industry, thus making the employee *de facto* an employer, and so giving all an interest in the success of the industry.

In each factory a committee, composed jointly of employees elected by their fellows and of representatives appointed by the employer, would be developed to consider suggestions for improvements and to settle petty grievances in their incipency. All questions which could not be settled locally would be referred to the Committee on Conciliation and Arbitration of the Board of Trade. An agreement would be made that no strike or lockout could occur without the reason being referred to this committee, which would have thirty days to investigate it in public meetings and announce its decision publicly, work continuing meantime, as before. Compulsory arbitration would not be advocated.

A planning department would be established to study existing methods and institute improvements. Standards of hours, wages and work, of lighting, fire protection, ventilation and sanitary conditions, etc., would be established. A uniform system of bookkeeping and cost accounting would be inaugurated in all factories to establish a common basis of competition. The seasonal fluctuations would be balanced by acquiring other work in the dull season, so as to make employment more steady. A central purchasing agency for factory supplies and raw materials would be established, as well as a sales headquarters, where samples would be displayed and in every way possible trade economies would be effected.

Here could also be accommodated representatives of the various activities existing in the State and city interested in industrial betterment, which would take part in the work.

Such would be the State Department of Labour, with its Board of Conciliation and Arbitration, and the National Employment Bureau. Here could also be housed the representatives of the Department of Health, the Fire Department, the Tuberculosis Committee, the Commissions on Congestion of Population, on Employers' Liability and on Under-employment, the Association for Labour Legislation, the Tenement House and Factory Inspectors, etc., etc. The charities are not mentioned, for the industry should attend to its own charities, as any industrial community, if isolated and properly organized, would have to do. (It should here be remembered that the employees in this industry, with their families, constitute a community of 175,000 people, comparable to such cities as Providence or Indianapolis.) In this connection there would be established relations with the various existing hospitals so that advice and treatment would be promptly and reasonably furnished to those found to be suffering from affections of the eyes, teeth, skin and from blood troubles and contagious diseases.

The Board of Education would be represented by lectures giving lantern-slide and moving-picture talks on hygiene of the factory and of the home; thus prevention as well as the cure of these ills would be instituted. Lessons in English and other fundamentals would be given.

After the project would be well started and the improvements above enumerated had been established, the desirability of moving the industry to a suburb would be considered. Lantern-slide lectures and booklets would inform employer and employee of the economic and social advantages of country house life over city tenement life, of country factory operation over that of the city. An industrial town could be built on the Garden City plan in from three to five years which would accommodate the factories and co-partnership housing for the employees and their

families. The removal of some 175,000 people from the congested sections of the city would help considerably in improving the health of the city. In this movement the Committee on Congestion would enlist the co-operation of the railroads and large building contractors.

To finance this project an operating company would have to be formed, composed of employers and employees. This company would raise a fund from the employers, each of whom would contribute .01 per day per employee, and from the employees, each of whom would contribute .01 per day, all in payment for the benefits derived from the privileges supplied. This fund would amount to nearly \$500,000 per year, which would make the project self-supporting. As this fund would be kept in the co-operative bank, all surplus accumulations would be invested in the industry and the dividends be paid to the stockholders.

When the industry in other cities in the State would be similarly organized there would be established a State Board of Trade, supervised by the State Board of Labour at the State Capital; and when it would be similarly organized in other States there would be a National Board of Trade, supervised by the Department of Commerce and Labour at Washington.

In this proposition it was represented that it is largely through ignorance of simple matters that present conditions exist, and that the cure is not to be accomplished by legislation, infrequent inspection and punishment for lapses. This project is based on developing educational centres in the industry, for promulgating knowledge of sanitary conditions and the principles of scientific and economic business management among its members, with the belief that education will most quickly and permanently achieve the results desired. Every feature referred to has been successfully applied on a smaller scale, so that it is known to

be individually economic and feasible; and as for the rest, it is merely applying the principles of democracy to an industrial community.

The need of improvement in methods in the industry is very great, and the saving which could be thereby accomplished would be proportionately large.

There are many organizations which are now doing industrial and civic betterment work in a haphazard and individual manner, and find great difficulty in accomplishing anything of moment, on account of the method of approaching the problem which they are compelled to adopt and the inertia of the people they endeavor to reach. By combining and centralizing these forces in the plan as outlined, and by intelligently controlling, correlating and directing them, their helpfulness can be made available in enhancing the benefits which would be projected. The public is tired of paying for the results of ignorance and inefficiency and for the inconveniences attendant upon industrial strife. It would, on the contrary, be glad to pay an equal amount for their cure and prevention.

It is strange how slow we are to realize tendencies, so gradual are their growth. The United States has changed from an agricultural nation, shipping our food products all over the world in our own merchant marine, to a manufacturing nation with no ships, without anyone, during the process of change, making the slightest effort to direct the tendency or to even think it possible to do so.

Meanwhile, there has been a tremendous waste of labour and materials, and the loss of health, of limb and life has been appalling.

The Department of Agriculture was formed in 1889 and the Department of Commerce and Labour in 1893, and it was not until 1903 that that industry was recognized as being of sufficient importance to establish, as sections of the latter, the Bureau of Corporations and the Bureau of Manufactures. Now, however, the for-

mer of these bureaus is beginning to loom large in importance, and there is a decided tendency to develop administrative activities in it and to place industry under its control.

At the present time any man, by applying to the Secretary of his State, can obtain, for a nominal sum, a charter which, regardless of his experience, or reputation, or capability, grants the privilege to establish a manufacturing enterprise to do practically anything, anywhere, at any time, without recognizing any obligation or responsibility for its effect upon the public at large, the community in which it is located, or the people it employs, notwithstanding the fact that the latter are all a part of the State by whose grace the privilege has been granted.

It should be realized, however, that an employer, by virtue of the continuity of his control over his employees during the greater number of their waking hours, has a more immediate and permanent effect upon their health, their character and their intelligence than their doctor, their minister or their teacher, whom they see only occasionally, and yet each of the latter has to spend a long term of years in the preparation of his profession and must receive a diploma before he can practice.

Now it seems that, as long as there is a lack of uniformity of laws in the different States, charters to corporations doing inter-State business (and almost all corporations that amount to anything are included in this category) must be of the general character described. If, however, the Bureau of Corporations (and really the Department of Commerce and Labour ought to be reorganized as a Department of Industry) carries out its present intention, it will establish an administrative system and grant charters to corporations doing inter-State business, and these can be drawn embodying some guarantees as to sanitary conditions to be observed in shops—maximum hours of labour and minimum wage of em-

ployees, and such other restrictions as the civilization of the time has determined to be necessary. Such charters should have a time limit—say for a year—with the privilege of renewal if the guarantees are met, or they may be revoked if, upon investigation at any time, the guarantees fail.

All corporations would have to register in the Department of Industry of those States and in the Bureau of Industry of those cities in which they do business, and would be amenable to the State laws and municipal ordinances of the locality where they operate.

The Department of Industry would, in each State and large city, have a headquarters of sufficient size to properly carry out its functions, one of which latter would be to see that peace between the constituent elements of corporations—viz., employer and employee—should be maintained. Thus Industrial Peace Palaces, being headquarters of the National Government where all its local officials would be grouped, would be established all over the country.

In large cities like New York, where there are many shops in an industry, this tendency towards industrial collectivism should be encouraged. The employer and employees of each shop respectively should annually elect representatives to a general convention of their industry at which a Board of Trade such as was suggested for the cloakmakers would be elected and established in a building, to represent the interests of the local industry, and this Board of Trade would be the local body through which the nation, the State, the city, or the individual would be able to negotiate with a whole industry as a group instead of individual enterprises.

We do not have to go far for a precedent in this direction. Seven years ago the building trades of New York City were so beset by internal strife between employers and the

various craft unions that building operations were practically suspended by a continuous succession of strikes.

Finally, at a conference of a large number of employers, it was proposed that an effort be made to establish a joint board of arbitration, composed of representatives of the employers, through the Building Trades Employers' Association, and the Employees' Unions, some thirty-two in all. After considerable negotiation, a closed shop arrangement was entered into and a General Arbitration Board was established and a headquarters secured, the expenses of which were shared equally between the Employers' Association and the unions.

For seven years industrial peace reigned, and, although the Board is at present technically disbanded temporarily, no strikes or lockouts occur, and negotiations are afoot for its re-establishment.

Then, again, the National Metal Trades Association, after a strike with the Machinists' Union extending all over the country, has for the past eleven years carried out an open-shop arrangement, with headquarters in many cities, with union and non-union men working together harmoniously. After the settlement of the recent express companies' strike the employees of the American Express Company formed a union. The company at once offered co-operation and rented and equipped a house for its accommodation.

Mr. Carnegie, who has probably given as much thought as anyone living to the subject of international peace, has decided that the best way to bring about a cessation of war is by providing a building where the representatives of the contending factions can be housed for the discussion and settlement of their differences, and has backed up his convictions not only by supplying such a building at The Hague at an expense of some two millions of dollars, but by donating ten millions more to put into effect the provisions

necessary to make his conclusions effective.

Thus by deduction is pointed out the direction in which to proceed in order to secure industrial peace.

The housing of the joint committees of employers and employees of an industry in a building would not only cause a discontinuance of the ridiculous war footing between the two parties, who are actually working together in a common interest, but would also bring about an efficient administration of the industry as a whole. But these committees would have to be paid well to obtain the results outlined. At present they are paid nothing, and the expectation of receiving something for nothing is not usually realized. The present arrangement, whereby grievances developing in a shop are reported by the employee to his union and by the employer to his association manager, simply results in friction, and cannot but be temporary.

With each industry so established and a National Department of Industry, with local branches, formed to meet the new conditions, not only would co-operation between capital and labour be fostered under governmental control—which, to many minds, is the coming solution of the labour problem—but activities would be established whereby forces could be controlled and tendencies directed so as to prevent industrial evils developing beyond the incipient stage.

The Fifth Avenue Association has appointed one committee to confer with the joint committees of the cloakmakers' industry to secure co-operation towards lessening street loitering by its employees by means of the proposition outlined above or otherwise, and another committee to confer with the Borough President regarding legislation looking towards more uniform architectural effects and adequate building construction on its street.

(The results of these conferences and of further developments will be given later.)

SAMRIT

"THE PERFECT OR AUSPICIOUS ALLOY" OF THE ANCIENT SIAMESE. ITS FORMULA
DISCOVERED IN AN OLD MANUSCRIPT

BRONZE, as the finds of bronze hatchets and arrow-heads in limestone caves and other places of deposit of prehistoric remains in Siam shows, was known throughout Indo-China since the earliest times, though, according to old records, the art of bronze casting was introduced into Siam by the Chinese in the eleventh century.

An interesting point about the ancient bronze figures of Indian divinities and of Buddha—the latter being found in North Siam in great numbers on the sites of ancient temples which have been crumbling for centuries, leaving the majestic bronze figures standing inclosed by great forests, with their only worshippers the wild beasts of the jungle—is the perfect condition in which they remain after exposure to a tropical sun and rains for centuries.

These ancient bronze figures, so long neglected, testify to the early employment of the art of the bronze founder in the religious cults of Siam. One of the most beautiful objects of art that the Siamese ever produced is the statue of Buddha standing in the city of Pitsanuloke, and dating back to the beginning of the eleventh century.

This figure, as well as many others, is cast from a bronze the natives call "Samrit"—the perfect or auspicious alloy—and its present state of preservation goes far to show that the name for this bronze is an appropriate one.

For a long time the composition of this bronze remained a mystery, but a few years ago Major Gerini dis-

covered its formula in an old Siamese manuscript which belonged to the late King. The following is a translation of this old formula for "Samrit" bronze:

Take 12 ticals (1 tical equal to one-half ounce avoirdupois) weight of pure tin, melt it at a slow fire, avoiding bringing it to red heat. Pour 2 ticals' weight of quicksilver, stir until the latter has become thoroughly absorbed and amalgamated; then cast the mixture into a mould, forming it into a bar. Take one catty in weight (80 ticals) of refined copper and melt it. Then gradually incorporate with it the amalgam, keeping in the meantime the fused mass well stirred.

When this has been done, throw into the crucible a sufficient quantity of ashes obtained from the stems of the *bua-bok* (terrestrial lotus) creeper, so as to cover the molten metal. Remove the dross with an iron ladle; the metal remaining is Samrit bronze. According to this recipe, the proportion of the ingredients employed in the manufacture of the alloy in question thus proves to be: 85.11 copper, 12.76 tin and 2.13 quicksilver. A late qualitative analysis shows that this alloy also contains traces of gold, silver and iron.

This bronze, which has certainly proved its lasting qualities, was supposed to be endowed with certain mystic ones, and was used in old days for casting vessels and implements for sacred uses, and its formula proves of interest, in view of the many bronze alloys of the present

day, some of which, it is feared, would not stand the test it has and come through it so little damaged.

The art of casting bronze, Major Gerini states, still forms quite a home industry in Siam. The method followed is to mould a figure in clay and coat it with wax, and then to apply a coating of clay; the wax is melted by the application of heat and the molten metal poured in; when cold, the mould is broken and the figure cleaned and polished. In the temples of Bangkok may be seen many fine specimens of modern statues of Buddha, which compare favourably with similar art in other countries.

American Railroad Man Appointed Director of the Mechanical Department of the Central Railroad of Brazil

IN connection with the articles appearing in this magazine on The Railroads of Brazil, it is of interest to note that an American, Mr. F. O. Walsh, who, as head of the mechanical department of the Atlanta & West Point Railroad, is so well known in the South, has been appointed director of the mechanical department of the Central Railroad of Brazil, with headquarters at Sao Paulo.

In his new position Mr. Walsh will have entire charge of the mechanical department of 5,000 miles of track.

When Mr. Walsh decided to accept the offer from Brazil and tendered his resignation to the Atlanta officials, he found them unwilling to accept it, and, instead, they proposed a year's leave of absence, their idea being that he might become dissatisfied with South America and desire to return to their road; and it is under this arrangement that Mr. Walsh sailed from New York on February 18 to take up his new work.

A party of twenty or more of Mr. Walsh's railroad friends went down the bay on a special tug to bid him "Au revoir."

Electrical Engineering at the Massachusetts Institute of Technology

THE progress of the graduate electrical engineering work at the Institute of Technology is indicated by the number of students who are candidates for Master's and Doctor's degrees, which number is now greater than last year. The number of students in the undergraduate course in electrical engineering is also steadily increasing, so that additional teaching staff is being added to the corps of laboratory instruction.

Various lines of research are being carried on in the department, mostly under the direction of Professor Pender and Professor Wickenden. Some of these relate to the effects of heat treatment on the magnetic qualities of silicon iron, certain transient phenomena that may occur in long electric circuits, the effect of high frequencies on the permeability of iron, the effective resistance and reactance of steel rails when conveying alternating currents, the selective action of spark gap lightning arresters with respect to frequency, the reflection of light from walls or ceilings, the disruptive strength of rubber insulated coatings on wires, etc. Certain of these are continuations of work started last year, and researches in each will be carried on as may be convenient and needful to get knowledge of the phenomena under investigation.

The results of the thesis research of Dr. Harold Osborne, on whom the degree of Doctor of Engineering (the first conferred by the Institute) was conferred last June, were embodied in a paper presented before the American Institute of Electrical Engineers at its October meeting and brought out an interesting and valuable discussion.

The subject of illumination and photometry has been added to the subjects taught in the electrical engineering department. This is to be treated from the standpoint of what is generally called illuminating engineering and is made an optional

study. The instruction is by lectures, recitations and laboratory work under the direction of Professor Wickenden, who is the author of a well-known book on "Illumination and Photometry."

The new buildings for the Department of Practical Mechanics were dedicated at Purdue University recently. The main building contains 25,000 square feet of floor space and will accommodate 400 students at one time in drawing, while the lecture room seats 300 and there are two class rooms having a capacity of 60 students. The shops cover 43,000 square feet of ground, and will accommodate 350 students at one time. The buildings, as a whole, constitute what is probably the largest and most completely equipped plant for the instruction of students in shop practice in this country, and in their construction and use the object ultimately sought is to teach manufacturing in the broader sense rather than manual training.

Under the direction of the Department of Theoretical and Applied Mechanics of the University of Illinois there has been recently carried out an important floor-load test of a reinforced concrete warehouse in Minneapolis, Minn. The test was on an unusually large scale, eight floor panels being loaded, and a successful attempt was made to measure the stresses actually present in the steel under load.

The Second International Congress of Refrigerating Industries, which was held at Vienna, Austria, October 6 to 12, proved an exceedingly successful meeting. The Third International Congress is to be held in the United States in 1913. For information concerning details, etc., address Mr. E. F. McPike, Chairman Press Committee, American Association of Refrigeration, Chicago Ill.

Book Notes

A volume which will be of more than ordinary interest to all college graduates, as well as to those who are planning to go to college and are undecided which to enter, is Dr. Edwin E. Slosson's "Great American Universities." The work presents, in a frank and forcible manner, an exact statement of what the leading universities of the country are doing. The unprecedented growth of universities in recent years and their effort to conform or to resist conformity with the demands of the times have effected such a transformation that hitherto it has been well-nigh impossible to get a clear idea of their present condition and relative standing. A list of the larger universities arranged in the order of their size, wealth, scholarly productivity or other objective criterion, has surprises for almost every reader. He finds in the list and near the head of it, perhaps, names of institutions about which he knows little, and probably some of those whose names are most familiar to him are really very different from his conception of them, derived from their history or from early acquaintance.

The Macmillan Company, New York.

We have just received a copy of Henley's "Twentieth Century Recipe Book," edited by Gardner D. Hiscox. Rarely has a book been published containing such a vast amount of useful and practical information between two covers. The subjects it treats upon are countless, and the work should be seen to be appreciated. We are impressed with the idea that, if a person could attain a fair knowledge of all that the book teaches, it would be better in many respects than a collegiate course. The price of the book, bound in cloth, is \$3; half morocco binding, \$4. Published by the Norman W. Henley Publishing Company, 132 Nassau street, New York.

Gifford Pinchot, whose name has been associated with most effective work in forestry and the conservation of natural resources in the United States, was born at Simsbury, Conn., in 1865, and, after his graduation from Yale University in 1889, he studied forestry in France, Germany, Switzerland and Austria, and in 1892 he began systematic forestry work in the United States at Biltmore, N. C. In 1896 he became a member of the National Forest Commission, and held the office of Chief of the Forest Service of the United States Department of Agriculture from 1898 to 1910. Since 1903 he has been Professor of Forestry at Yale University. In 1892 he inspected the forests of the Philippine Islands and made recommendations concerning them. He has also served on the following Government commissions, viz.: on organization of Government scientific work, on public lands, on departmental methods, on the inland waterways commission, and on the commission on country life. He is now chairman of the National Conservation Commission, and was appointed chairman of the joint committee on conservation by the conference of governors and national organizations at Washington in 1908.

Dr. Pinchot is a Fellow of the American Association for the Advancement of Science, a member of the Society of American Foresters, of the American Forestry Association, of the Royal English Arboricultural Society, of the American Museum of Natural History, of the Washington Academy of Sciences, and of the Engineers and the Biological Societies of Washington. He has devoted his energies to the preservation and scientific use of the forests of the United States, having visited every part of the country from Canada to the Rio Grande, and ranks among the great benefactors of the land by his earnest devotion to the cause of scientific conservation.



GIFFORD PINCHOT, D. Sc., LL. D.

See Reverse Side

CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

VOL. XXXIX

APRIL, 1911

No. 6

METAL SAWING MACHINES

By Thomas R. Shaw

THE cold iron sawing machine has, during the past few years, become one of the most useful tools in the machine shop. Its use is steadily on the increase, as the action of a saw not only provides one of the quickest methods of dividing material, but also leaves a well-finished end where the cut has taken place. These machines are extensively employed in girder work, cutting up bars, rails, and for many similar purposes. They are arranged with the saw blades placed in every conceivable position for cutting off pieces on large castings, and they are used for cutting off tubes and electrical cables, for sawing plates and every section of iron or steel bar.

The improvements in the construction of metal sawing machines during the past ten years have been as great, if not greater, as in any other class of machine for working metals, and this notwithstanding a certain amount of prejudice which existed against their use.

The causes for such prejudice hitherto may be summed up in the following points:

1. Difficulty in obtaining good saw blades;
2. Inefficient means of sharpening;
3. Bad construction of machines;
4. No means of keeping the teeth from choking and breaking;

5. Inefficient lubrication for the saw.

Nowadays these features are entirely eliminated. We are able to get saw blades of the highest quality made from high-speed steels; improved means of sharpening the teeth have been adopted, machines have been re-designed with a more rigid construction and a smooth, powerful drive, and with a thoroughly efficient system of lubrication.

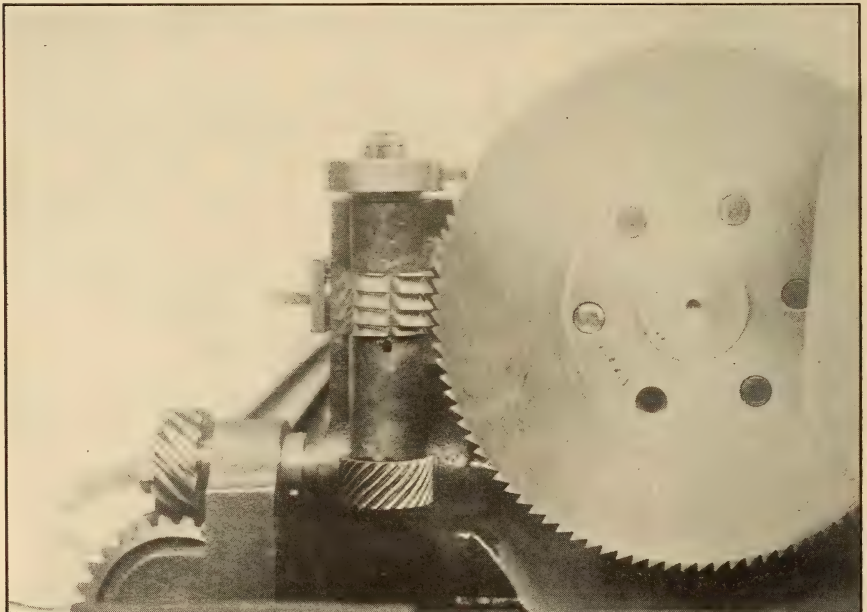
There is not the slightest doubt that the results, both in quality of finished surface and speed of cutting, are dependent upon the condition in which the saw teeth are kept; and it is, therefore, of the greatest importance to keep them properly ground by means of a saw-sharpening apparatus. Many machines, especially the larger sizes, have a sharpening apparatus attached to the machine itself, which makes it possible to sharpen the saw blade without removing it from its spindle. If a saw blade is not true on its periphery, then a few teeth will do all the work and the rest will be idle. Probably the full amount of the feed will come on to one tooth, causing this to be broken off if it is not strong enough to stand the shock and extra duty which it was not intended to perform. This sometimes happens with saws ground on a

separate machine, and, though invaluable and indispensable as the saw-sharpening machines are at present, it is preferable to sharpen a saw on its own spindle.

A saw is essentially a milling cutter, and, as such, should be kept sharp. No one would think of using a gear cutter or a milling cutter with dull teeth, to guard against which possibility and keep the user constantly reminded makers always stamp these tools "Keep sharp." This applies equally so to the saw blade; in fact, it is even more important that a saw tooth should be sharp and its periphery true, so that each tooth is doing its proper share of work, than the milling cutter, because the tooth is not so strong. Yet we often see them jogging along with the teeth in such a condition that it is a wonder how they cut at all. Is it because of the trouble of removing the blade that this is so, or is the machine so busy it cannot be spared? In either case, therefore, an attachment by which the teeth can be kept clean and sharpened while actually working is

one deserving of serious consideration.

The trouble caused by cuttings getting in the teeth is well known. They are carried around by the teeth, and, on coming in contact with new metal, they often "jam," and are the cause of breakages or of unsightly grooves in the face of the work. The author has seen a flat spring attached to a saw carriage, placed in such a position as to give a little tap on each tooth as it went past. This little device proved very effective in removing chips. Messrs. Carter & Wright, of Halifax, have invented a little attachment by the use of which the teeth are kept clean and sharp while the machine is running. A bronze worm, or hob, having threads the same shape and pitch as the saw teeth, is placed behind the blade and in mesh with it. This hob is driven through suitable gearing so as to rotate as if it and the blade were a worm and wheel in mesh. Grooves are cut in the hob, and as these pass over the saw teeth they remove all the chips and dirt. Then on the same spindle there is fixed a piece of



AUTOMATIC SAW-TOOTH CLEANER AND SHARPENER. MESSRS. CARTER & WRIGHT, HALIFAX

emery, placed at the proper inclination to act across the face of the teeth, and this, working continually, acts upon them as a strop on a razor. A clean, true-running blade with a keen edge is the result, and there is no softening of the teeth through excessive grinding—another of the source of annoyances which have prevented full advantage being obtained from the use of cold sawing machines.

The secret of success in sawing, therefore, lies in three things:

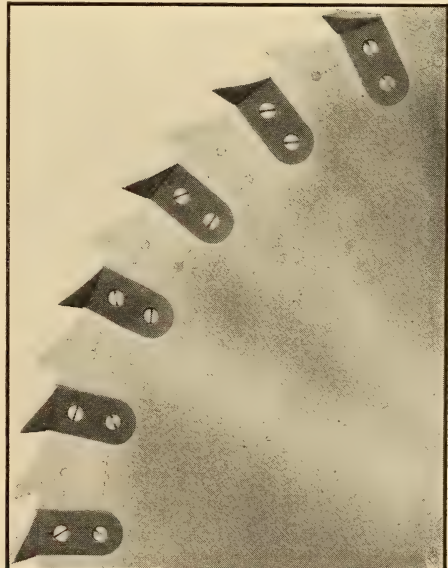
1. Keeping the saw teeth sharp;
2. Keeping the periphery true;
3. Keeping the teeth clean.

A saw blade is usually mounted on a spindle which centres it. It is then clamped between two large washers, one of which is generally a flange on the spindle, and the saw is driven by dowel pins attached to the flange. Hill's flush-side saw blades are riveted to a steel washer, and the whole is then bolted to the spindle flange by recessed head bolts. This construction enables projecting pieces, such as runners or gates of castings, to be cut off quite level with the castings. Some saw blades have every alternate tooth beveled and left slightly higher than the square teeth. These act as a roughing tool, taking the chip from the centre, while the wide teeth take chips from each side of the cut.

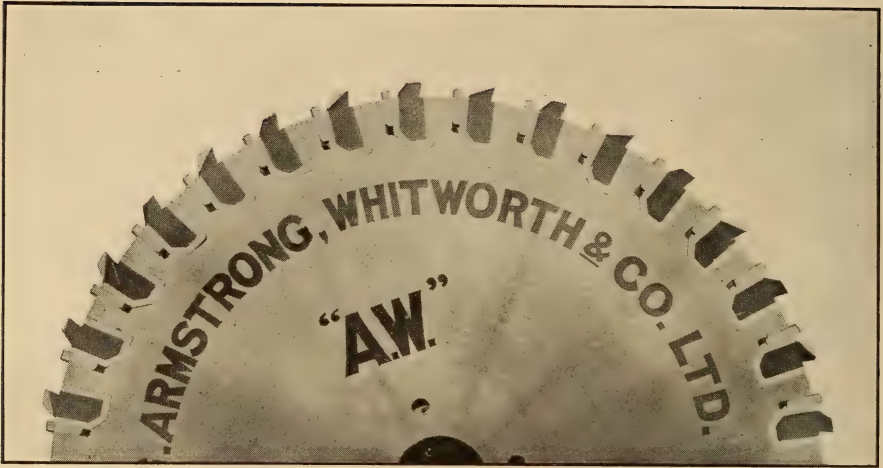
Much useful and excellent work has resulted from the use of saws made entirely of high-speed steel for metal slitting for armatures, turbines, and the cutting up of material generally; but for saws of large diameters the results have scarcely been so satisfactory, owing to the failure of such saws by cracking and breaking. To overcome these defects various designs of saws with inserted teeth have been introduced, having high-speed steel teeth fitted into a disc of some softer material, but very tough, so as to withstand the severe stresses encountered by cutting at high speeds and heavy feeds. Illustrations are given of such saws

as made by Messrs. Armstrong, Whitworth & Co., Ltd. It will be seen from the illustrations that in one case the teeth are fitted directly into the disc, in the sides of which are milled suitable recesses, the high-speed steel teeth being driven therein and afterwards firmly secured by rivets. Further, to prevent any tendency for the teeth becoming detached from the saw, the recess is machined undercut and the teeth formed to fit. All screws are dispensed with, and with the teeth forming part of the body the stresses of cutting are transferred to and resisted by the disc. The whole of the teeth, which may be easily replaced or renewed at will, all being interchangeable, are ground with side relief or clearance to facilitate easy and rapid cutting, so that it is only necessary to grind the tops or front faces of the teeth, which may be done in the usual forms of saw-sharpening machines. It is thus not necessary to remove the teeth to grind them. The teeth are arranged in staggered formation, so that cuttings are freely cleared.

Another design of saw, suitable for the heaviest class of work, has the



METHOD OF FASTENING TEETH IN DISC.
ARMSTRONG-WHITWORTH SAW



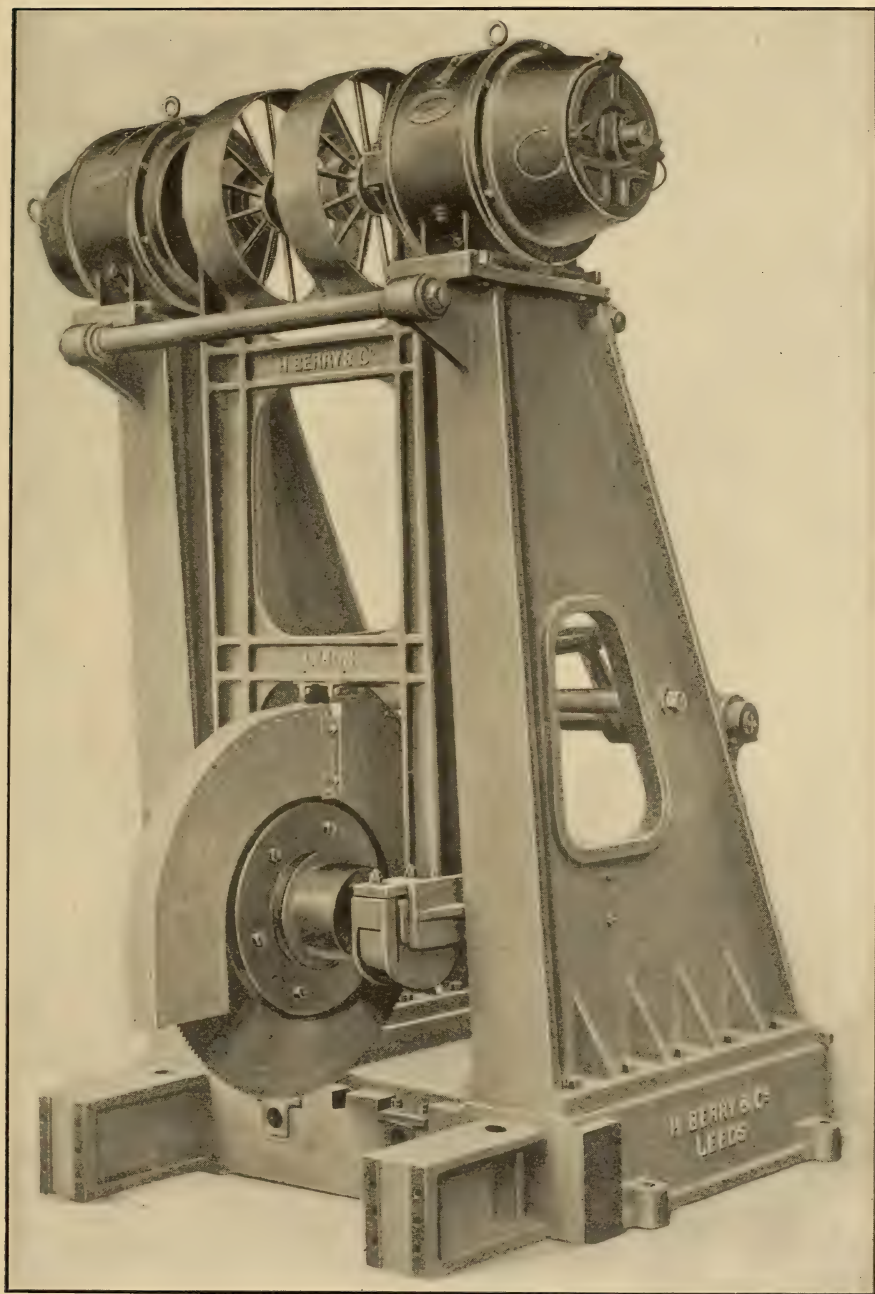
ARMSTRONG-WHITWORTH TYPE OF SAW WITH INSERTED TEETH OF HIGH-SPEED STEEL

teeth or cutters carried in a mild-steel pocket or holder, the combination being secured and held in position by means of a hardened steel wedge driven between the pocket and the opening in the disc. The tooth, pocket, wedge and disc are each machined with tongue and groove, so that any tendency to side movement is at once prevented. The degree of taper in the supporting wedge is such that, after it has been driven tight and hard into position, the combination of pocket and tooth is firmly secured in the disc. The great advantage resulting from the use of the pocket is the protection it affords to the disc in case of accident. The pocket may be compared to "a buffer State," and being made of softer material than the surrounding metal it sustains the force of any shocks that may be offered to the saw, and, by giving way, prevents accidents or breakages of more expensive parts. The great strength of the teeth of this saw opens a new field for sawing operations, as by its use much coarser feeds can be taken than with the saws previously used. It will also be seen that new teeth can be fitted with the greatest ease. Saws of this design from 24 to 72 inches diameter are extensively used at the Whitworth works. An average cut-

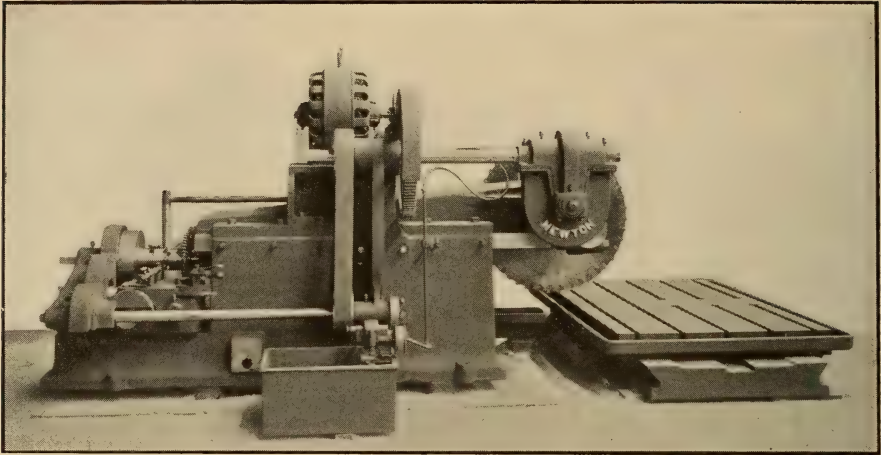
ting speed used is 90 feet per minute, with a travel of 1 inch per minute.

It will be of interest here to refer to the performance of a machine with two of these saws working together. They were used for cutting gas-engine crankshafts preparatory to the pins being turned, and changed a machine which was a failure with the old-style saws into a success. The machine works with a feed of $\frac{1}{2}$ inch per minute on mild-steel crank forgings up to $4\frac{1}{2}$ inches thick, cutting two gaps, each $\frac{3}{4}$ inch wide. On forgings from 9 inches to 12 inches thick the machine cut with a feed of $\frac{5}{16}$ inch per minute. The peripheral speed of the saw was 44 feet per minute. Similar types of saws are also made by Messrs. Saviile & Co., of Sheffield, and, being fitted with teeth made of their "Triumph Superb" new high-speed steel, are giving excellent results.

One of the most recent designs of sawing machines for crankshaft work is one having two complete right and left-hand machines carried on a base plate so that they may be adjusted to deal with single, double or triple-throw cranks, cutting the shaft to a definite length, both ends simultaneously, and cutting down the inside and outside of the crank webs



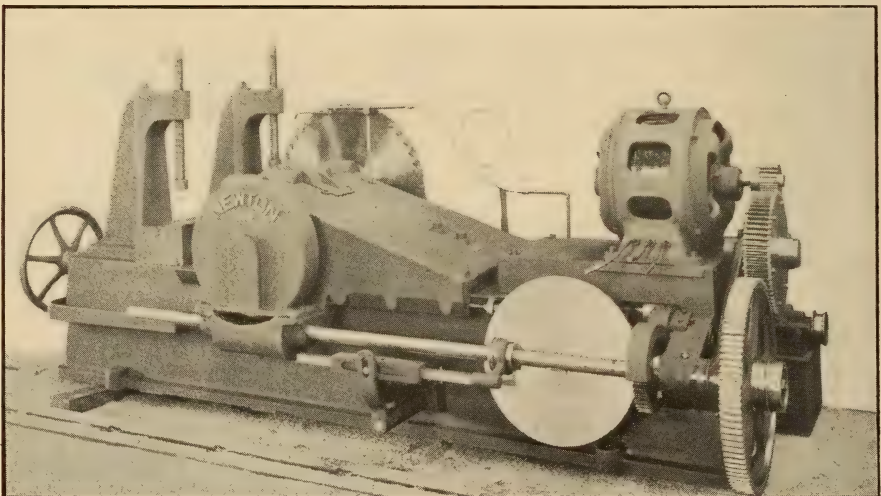
VERTICAL HOT SAWING MACHINE. MADE BY MESSRS. HENRY BERRY & CO., LTD., LEEDS



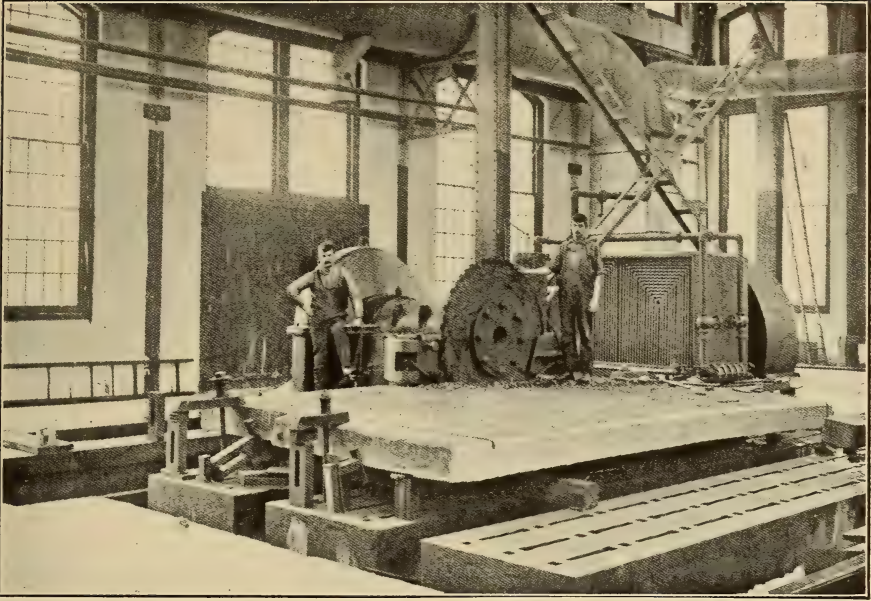
STEEL FOUNDRY COLD SAWING MACHINE. MADE BY THE NEWTON MACHINE TOOL WORKS, INC., PHILADELPHIA, PA.

to remove the surplus material. This is one of the features we see in machines to enable an increase in facilities for dealing with work, and another, but totally different machine, is one mounted on a turntable base for dealing with either straight or angular sawing. By the use of this the machines may be kept in one plane with the shop building and the machine turned round to the required angle. For long work, such as girders and channels, such a machine is a great convenience.

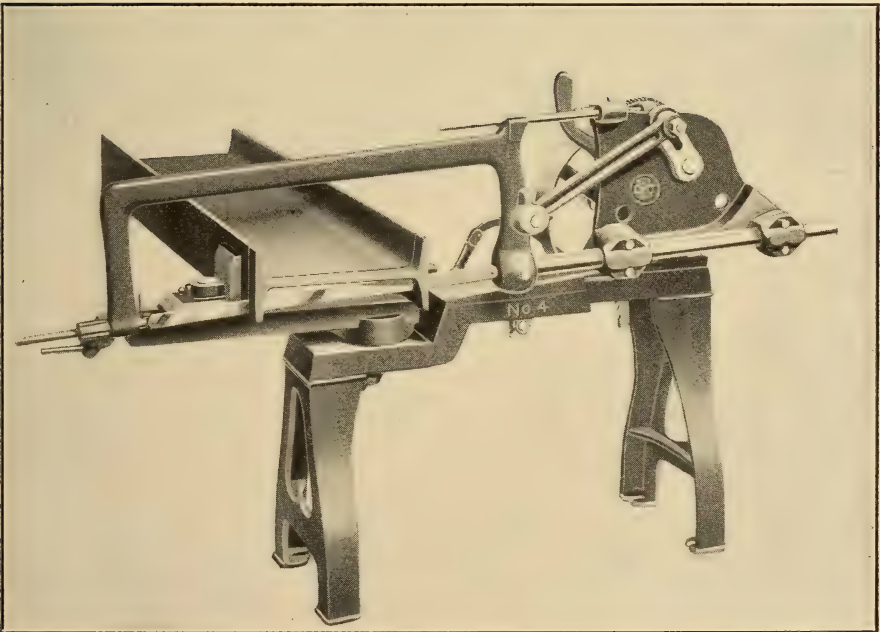
The improvements in the construction of sawing machines will, perhaps, be best seen by reference to the various photographs chosen as illustrations. Some of the makers—the Newton Machine Tool Company, for instance, who make a complete range of sawing machines—adopt the diameter of the blade as a unit, and for a given diameter of blade all machines are of identically the same general design, having the same size and design of parts of the same material, the only difference in the vari-



COLD SAWING MACHINE. THE NEWTON TOOL WORKS, INC., PHILADELPHIA, PA.



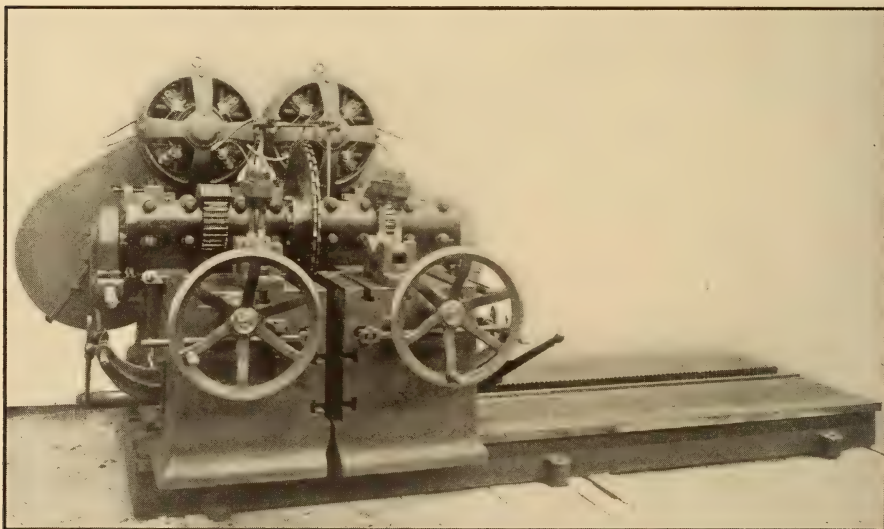
MOTOR DRIVEN ARMOUR-PLATE SAWING MACHINE. NILES-BEMENT-POND COMPANY



POWER HACK SAW. FRONTIER IRON WORKS, BUFFALO, N. Y.

ous types of machines being in the table construction. The greatest attention is being paid to the design of the carriage. Deep grinding surfaces are used for the slideways with square guides, the bearings on the under side being cast solid and the adjustments made by taper gibs. The centre of the saw spindle is placed as near as possible to the bed to ensure the utmost rigidity. The control of a saw carriage is just as important as that of a lathe carriage, and the saw blade should be under absolute control by the operator at all times. We

structional work, and is found in both the sliding carriage and lever types. The feed of a saw must not be greater than is required to cut through the greatest sectional area of the object to be cut. Thus, in cutting a round bar, the feed must be no quicker than is required to cut through the centre of the bar, whereas in starting into the bar the area is much less than in the centre. Consequently, it could cut at a coarser feed in the smaller area; but the feed must be no more than when cutting through the centre, and the



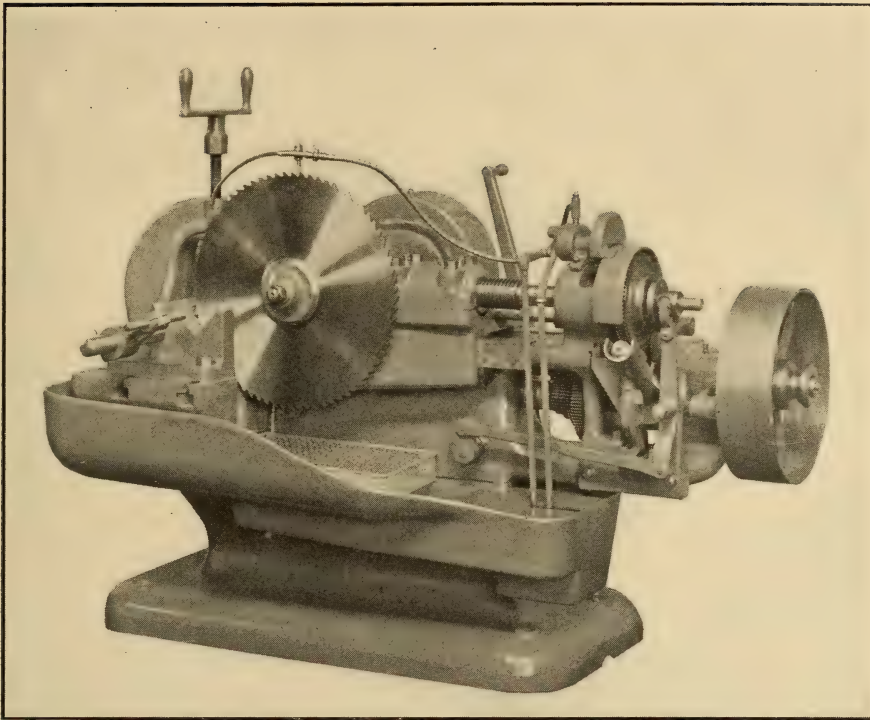
SIMPLEX SAWING MACHINE FOR CRANK-SHAFT WITH ADJUSTABLE HEADS. MADE BY NEWTON MACHINE TOOL WORKS, INC., PHILADELPHIA, PA.

see the grouping of controlling handles so that these may be all operated from one convenient position. Hand adjustment is usually provided, and a power feed and quick return.

For the drive the worm is very popular, as it insures a smooth and steady motion, without which it is impossible to obtain the maximum efficiency from the inserted tooth saws. The feed is by weight, by friction, and by positive gearing. Each has its own adherents. The weight feed is considered the most satisfactory for sectional and con-

structional work, and is found in both the sliding carriage and lever types. The feed of a saw must not be greater than is required to cut through the greatest sectional area of the object to be cut. Thus, in cutting a round bar, the feed must be no quicker than is required to cut through the centre of the bar, whereas in starting into the bar the area is much less than in the centre. Consequently, it could cut at a coarser feed in the smaller area; but the feed must be no more than when cutting through the centre, and the

same objection applies to other sections. On the weight-feed principle the feed automatically accommodates itself to the area to be cut, and no undue stress is put on the saw blade. Friction feeds are extensively used on the smaller machines, the two popular types being the disc-and-bowl and the "Sellers" friction disc. For the larger machines, and where use is made of the inserted tooth blades, positive gear-driven feeds are the rule, a feed box being generally embodied in the design. In order to avoid breakages, by the use of a positive feed one maker provides a



COLD SAWING MACHINE. MADE BY THE COCHRANE-BLY COMPANY, ROCHESTER, N. Y.

cushioned nut, which allows the nut to compress a spring and thereby reduce the feed should the saw come into contact with hard spots. The safety shearing pin is a popular device used in American machines. Should this pin shear from too great a pressure a new one can be easily inserted.

In former practice the blade was allowed to revolve in a pan of oil, depending on its adhesiveness for circulation; but the heat generated in using inserted tooth blades is so great that it is necessary to supply machines with a pump and piping to deliver the heat-distributing and lubricating fluids at the point of cutting.

In the Cochrane-Bly machines the feed screw is specially noteworthy. It is placed on the centre line of the saw spindle, and directly behind it, so as to give a direct and powerful feed. The trip motion is also a very neat feature. The lever which engages the feed is held in place by a

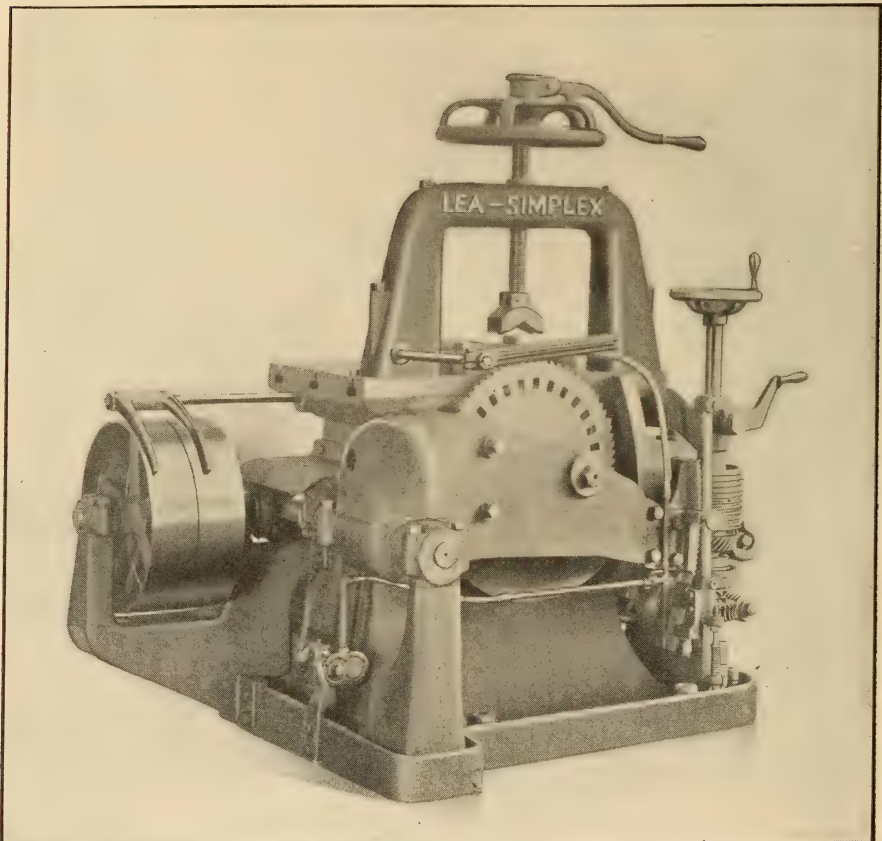
catch, which is released by the carriage on its forward travel when the cut is finished. As soon as the lever is released a spring disengages the feed gear and throws in a clutch which reverses the feed screw and returns the carriage rapidly until it strikes a stop which throws out the clutch.

A very useful type of machine is one in which the saw blade is carried by a swinging arm, and a weighted lever is used to give the feed downwards. A modification of this, specially intended for fitters' use and general utility, has the saw in a fixed position and a work-holder pivoted and moved radially up to the saw through a screw and hand wheel. A further modification—the Lea-Simplex—is a most interesting machine. This has a power feed upwards. The saw, being lifted against the action of gravity, has, consequently, a very smooth movement, there being no shock or jerky action. There is no

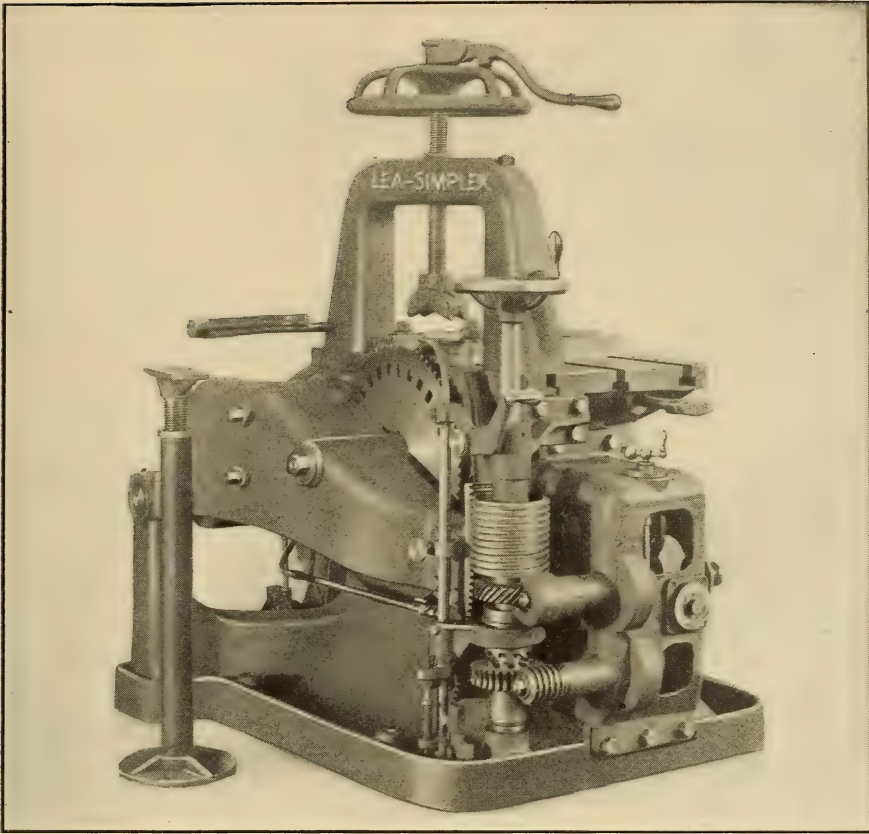
spring when the end of a cut is reached, nor even when the saw teeth come in contact with the work intermittently. The two illustrations of this machine clearly show the arrangement of the parts and the controlling handles. These are both power-feed and quick-return, with automatic stops. Sellers discs operate the feed, and these are regulated by a ball-crank handle on the top of the feed box. A dial on the front of this box shows the rate of traverse per minute. A hand wheel for adjusting the position of the swing arm is placed in a convenient location on the top of the worm shaft. A ball bearing is placed at the bottom of the worm shaft, and this takes the weight of the swing arm.

Another ingenious feature in this machine is the driving arrangement. The saw is literally pulled through the work, and the spindle has nothing to do but centre the blade. A chrome-steel sprocket wheel of very high tensile strength engages with radial slots in the blade itself, the part of the blade in contact with the sprocket being protected from side thrust by four tool steel guides.

The "cutting-off" problem is one of the most serious things the shop has to contend with, whether it be the cutting off of blanks for wheels, risers from castings, or bars into suitable lengths for stud and bolt work, especially so in such shops as do without a blacksmith and produce everything from the bar instead of from forgings. For cutting



THE LEA-SIMPLEX SAWING MACHINE. MADE BY THE LEA EQUIPMENT COMPANY, NEW YORK



ANOTHER TYPE OF THE LEA-SIMPLEX SAWING MACHINE

bars of almost any diameter, whether round, square, or hexagon, the special cutting-off machine patented by Messrs. Carter & Wright, Halifax, is a most efficient tool. Using a saw blade 12 inches diameter, $\frac{3}{16}$ -inch thick, and made of high-speed steel, this machine has cut off a 5-inch diameter bar in $3\frac{1}{2}$ minutes and left the end perfectly true with the bar. The principle followed in the design of this machine is similar to that of some of the cutting-off machines of the lathe type, in which the bar is rotated and a lathe parting tool is used for cutting. As a saw is used instead of the parting tool, this machine, therefore, combines the advantages of the lathe and the saw. When cutting a bar with a saw in an ordinary machine it is necessary to have a saw equal in diameter to

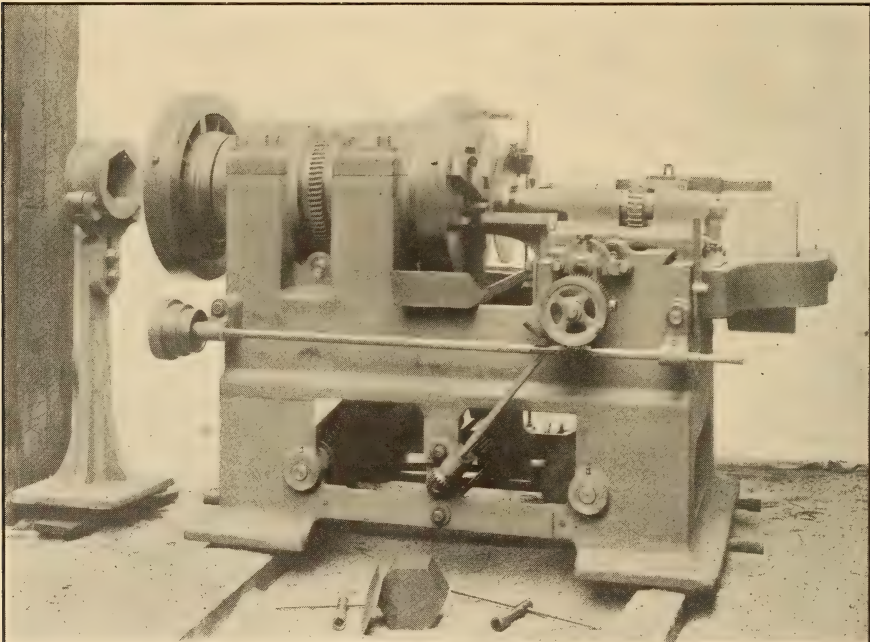
twice the diameter plus diameter of the clamping washers. In this machine, on account of the bar rotating, it is only necessary to cut to the centre, and a smaller saw is required—viz., equal in diameter to one diameter of the bar plus the clamping washers. For instance, a 12-inch saw will cut through a 6-inch bar. It has been pointed out that machines are built with the diameter of the saw as a basis, so it will be at once seen that smaller proportions are required for the saw carriage and less driving power is required. Further, as compared for cutting with the lathe type or with a larger saw with inserted teeth, the saving of material is considerable. The difference of cutting with a $\frac{3}{16}$ -inch-thick saw and a $\frac{3}{8}$ -inch tool on a 5-inch bar will save 1 pound of material, and

where large numbers of discs are required the small amount of waste involved in their cutting off is an important consideration.

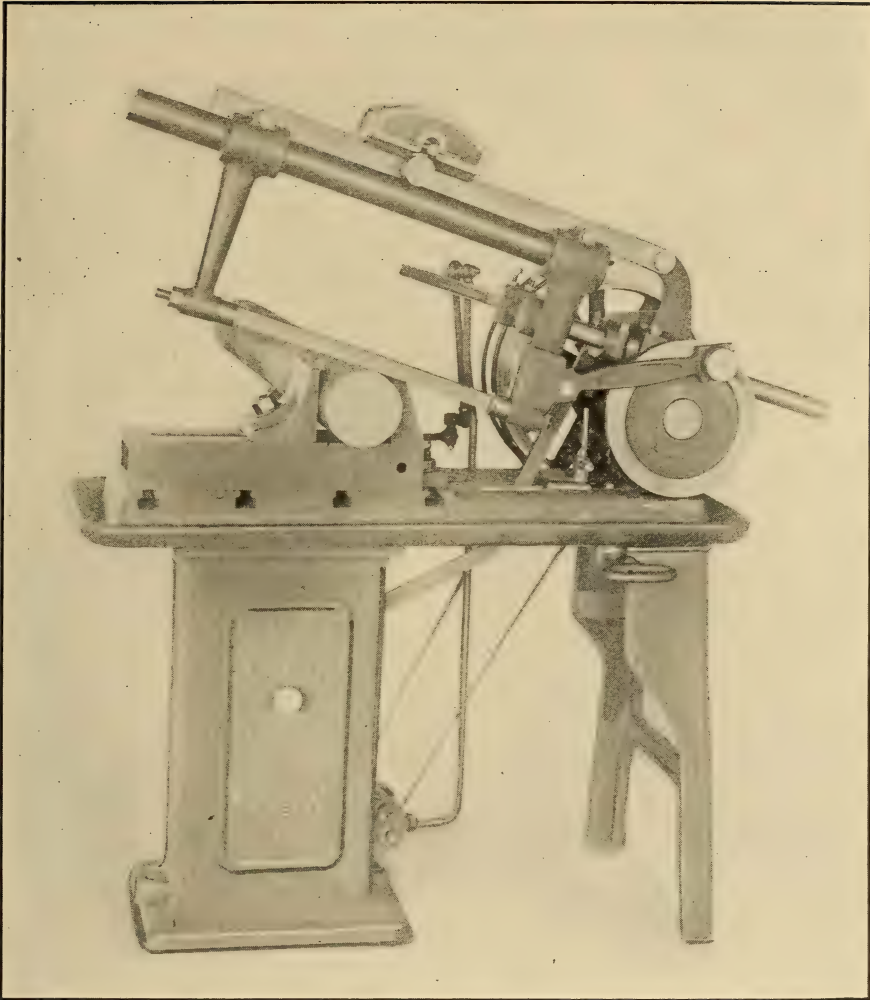
There are many features of interest in this machine. We have seen that the rate of feed is determined by the largest area of section cut; therefore, as the area diminishes the rate of feed can be increased. In order to keep the speed of the bar constant at the point in contact with the saw, an accelerated speed device is used, so that the bar automatically increases in speed as the cut gets deeper in. Then, as the arc of contact with the teeth has become less, the feed also can be accelerated. This is done through the medium of two motions. As the feed motion is derived from the bar driving motion, it is naturally accelerated, but not in proportion to the reduction in area, so a supplementary ingenious device is used, as follows: Instead of the traverse screw being connected direct to the saw carriage, it moves a nut which slides in the slotted arm of a bell-crank lever. At the begin-

ning of the traverse it pulls on the long radius of the arm and gives a slow motion. The nut gradually rides down the slot, thereby decreasing the leverage and increasing the speed at which the lever turns on its pivot. The other arm of the lever is connected to the carriage in a similar manner, working vice versa, and so doubly accelerating the speed of traverse, the combination being so great that the final speed of the carriage is thirty-two times as great as the commencing speed.

The accelerating motion to the bar is obtained from long conical pulleys underneath the bed, provided with an automatic belt shifter. The driven cone is provided with a positive starter, so that whatever the diameter of the bar being cut the machine can be instantly started at the correct speed and feed. This takes the form of a supplementary drive at the rear of the machine, where a belt drives the driven cone shaft through a pulley having a free wheel motion, which starts up the motions without any slipping—one of the



CUTTING-OFF MACHINE. CARTER & WRIGHT, HALIFAX



ELECTRIC DRIVEN HACK SAWING MACHINE. E. G. HERBERT, LTD., MANCHESTER

difficulties encountered with cone driving. As soon as the driven shaft exceeds the speed of the free wheel pulley this, of course, runs idly.

The hack sawing machine is probably one of the greatest labour-saving machines we have in the machine shop, and what a development we find in it from that useful hand tool, the bow saw! To replace the human hand with a hand of iron and give the bow a power movement was the first of the obvious improvements to be made, but who would have

anticipated hack-sawing machines of such sizes and weights as the machines shown in the illustration?

The hack-sawing machine consists essentially of a frame carrying a thin saw blade, to which is given a reciprocating motion by a crank and connecting-rod. The weight of the saw frame and its supporting parts gives the necessary pressure to effect the cut, and this pressure is regulated by means of a counterbalance weight. Messrs. E. G. Herbert, Ltd., Manchester, make a hack-saw machine which is more adaptable for

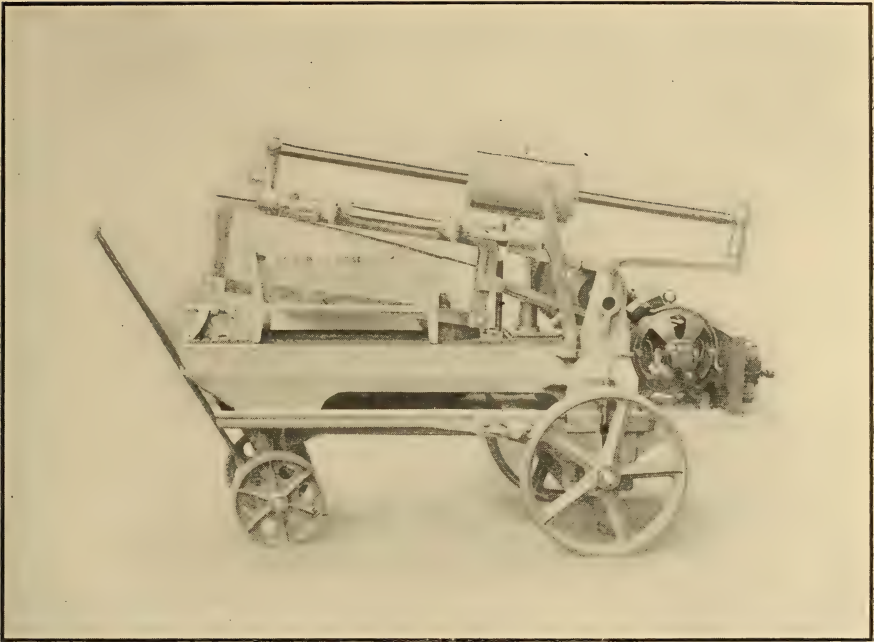


BURTON-GRIFFITHS HACK SAW. SHAPING MACHINE TYPE

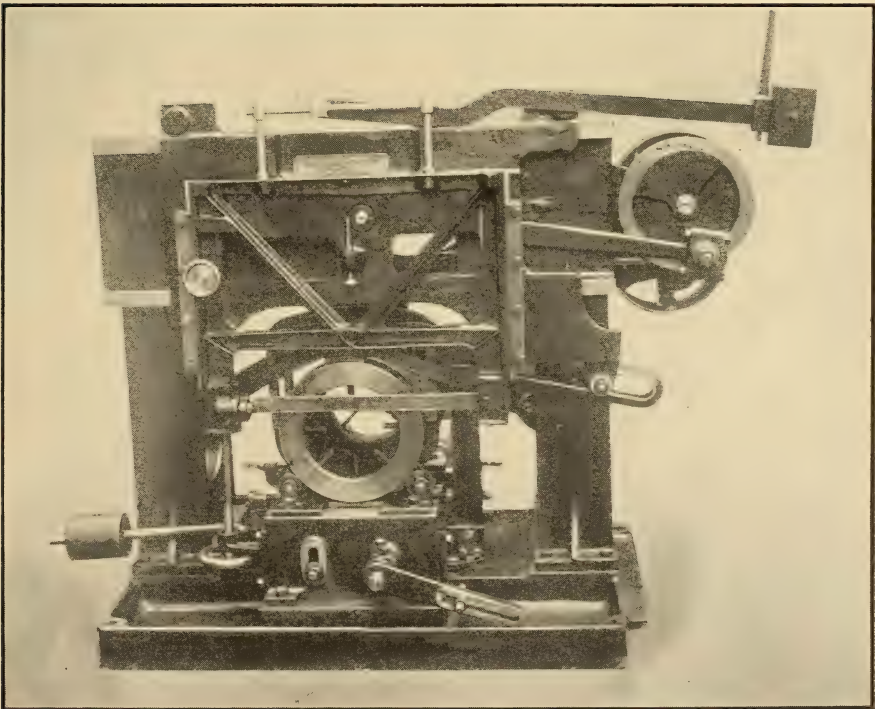
heavy work than the common pattern of machine, one size being capable of cutting a girder 30 inches deep and 18 inches wide. It embodies a principle in hack-sawing which has since become recognized as a vital feature in this type of machine—viz., that of altering the angle of the saw blades so as to attack fresh surfaces. The advantage of so doing is obvious on a little consideration. If a considerable length of saw is resting on a surface, the pressure which is applied, and which is somewhat limited by the strength of the saw, is distributed over so many teeth that a satisfactory cutting action is not obtained, the saw tending to slip over the

work. In Herbert's machine the guides of the saw frame are mounted on an eccentric on the main shaft center, the eccentric being so geared as to make a portion of a revolution after every twenty strokes of the saw. The effect is to change the inclination of the saw periodically, causing it always to be cutting on a "corner" instead of bearing on the whole width of the work. This allows the teeth to penetrate deeply, and permits the use of a thin, fast-cutting blade.

Increased economy of production is a point which appeals to engineers of every class, and hack-sawing machines are not behind in having various modifications to enable them to



PORTABLE HACK SAW MADE BY BURTON, GRIFFITHS & CO.



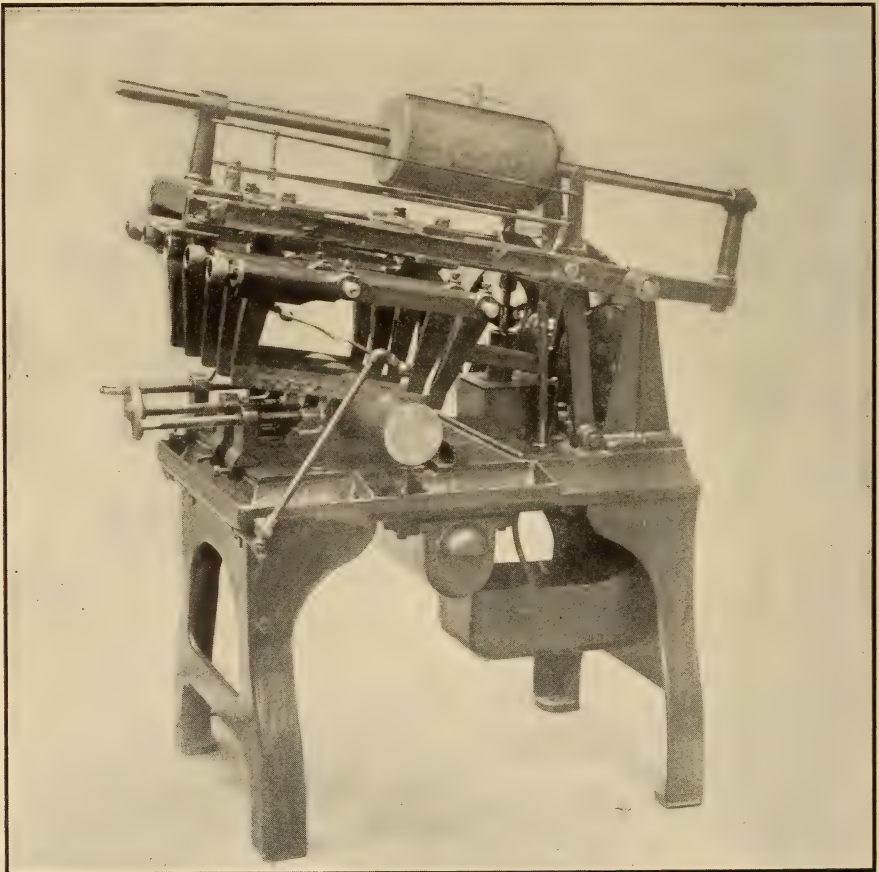
HACK SAWING MACHINE TO CUT 10-INCH DIAMETER BARS. JOHN HOLROYD & CO., LTD., ROCHDALE

"cut costs." One machine is provided with two vertical bows, thereby enabling a bar to be cut through in one-half the usual time. Immediately one blade reaches the centre of the cut an automatic device thrusts it back and leaves the other blade to cut clear through.

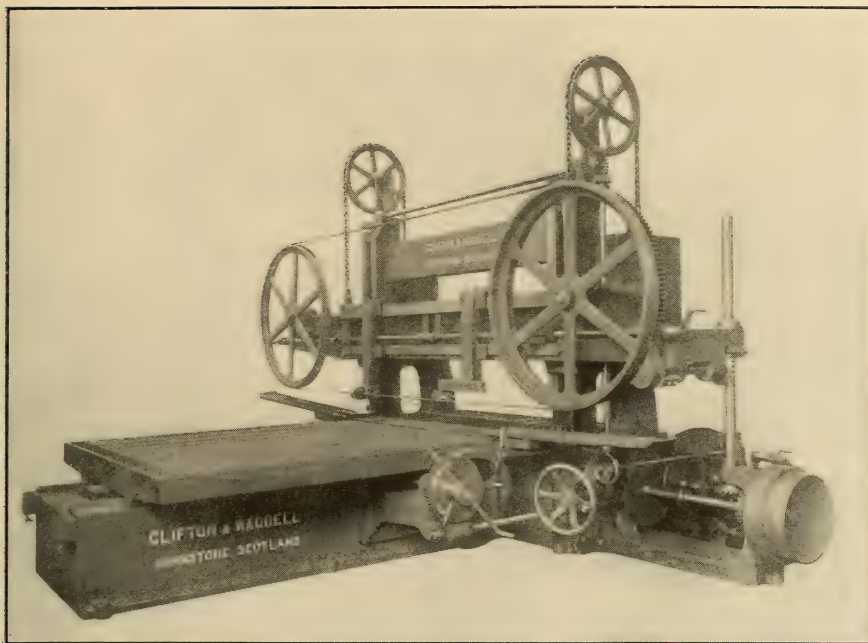
Some excellent examples of up-to-date hack-sawing machines are the "Acme," supplied by Messrs. Burton, Griffiths & Co., Ltd., London. A noteworthy feature in these machines is that the saw blades are lifted off the work on the return stroke by means of an oil ram. One of the illustrations shows a multiple sawing machine, and this is provided with a hydraulic lift, which raises the saws up by power with the full weight on after the cut is completed and

lets them gently down on to the work again. The motor-driven girder saw illustrated is specially constructed on a bogie truck so that it can be conveniently taken to any part of the works. The average cutting time for circular bars is as the square of the diameter; thus, a 1-inch bar is cut in 1 minute, a 3-inch bar in 9 minutes, and a 6-inch bar in 36 minutes. Cast steel is sawn at about one-half this rate.

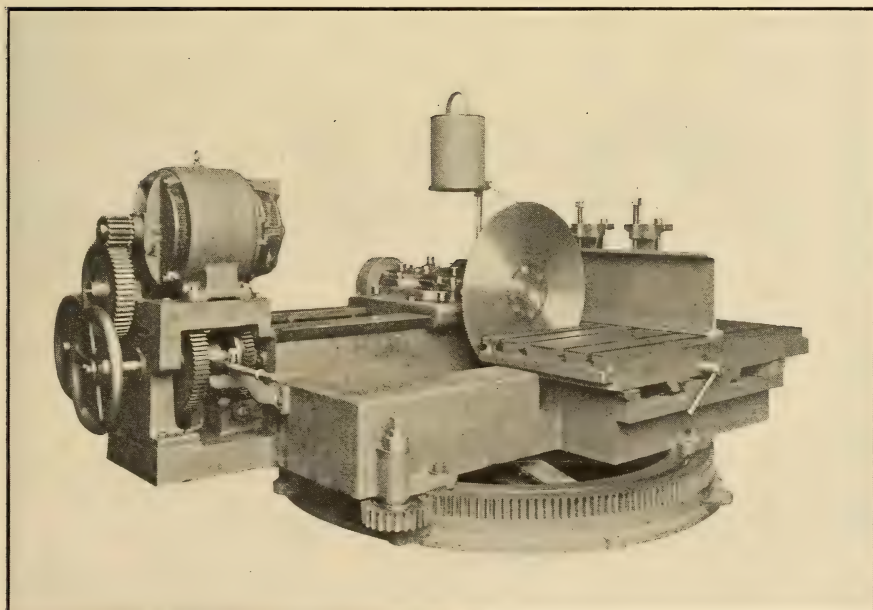
The shaping machine has often been advocated as being capable of doing a lot of useful work with a bow saw. Messrs. Burton, Griffiths & Co. have a machine of the pillar shaping machine type specially arranged to use hack-saws. This machine has two parallel saw blades, and their position relative to the work



MULTIPLE HACK SAW. BURTON, GRIFFITHS & CO.



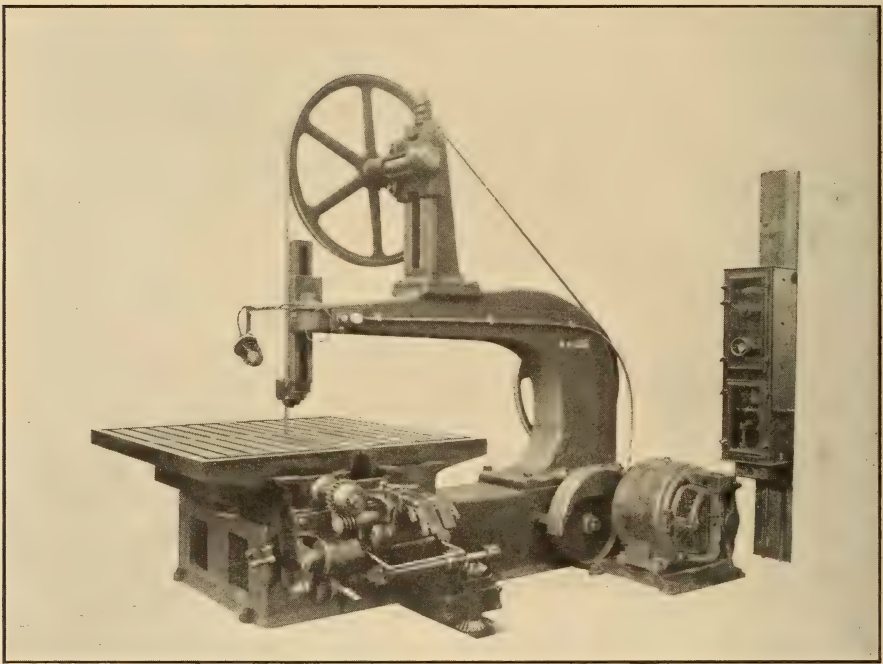
HORIZONTAL BAND SAWING MACHINE. CLIFTON & WADDELL, LTD., JOHNSTONE



COLD SAWING MACHINE WITH SWIVELLING SAW ON TURN-TABLE BASE, 36 INCHES. CLIFTON & WADDELL, JOHNSTONE

may be adjusted backwards or forwards just like the ram of an ordinary shaper. The table has both horizontal and vertical traverse, so that the work can be brought into any position under the saws. The two saws can be adjusted so that there is a minimum distance between them of $\frac{1}{2}$ inch, or a maximum distance of $4\frac{1}{2}$ inches. The use of the parallel blades makes the machine specially suitable for cutting out joints of all sorts, and, as one or two

a strong base, on which are mounted two uprights carrying a cross-slide on which a carriage is mounted; this, in turn, carries the saw frame in a vertical slide. The horizontal slide is moved to and fro by a long connecting-rod and crank. It runs on rollers, and so works freely. As in the case of the smaller machines, the saw frame is balanced, and thereby allows the pressure on the saw to be regulated. The bar to be cut rests on two roller brackets and is turned



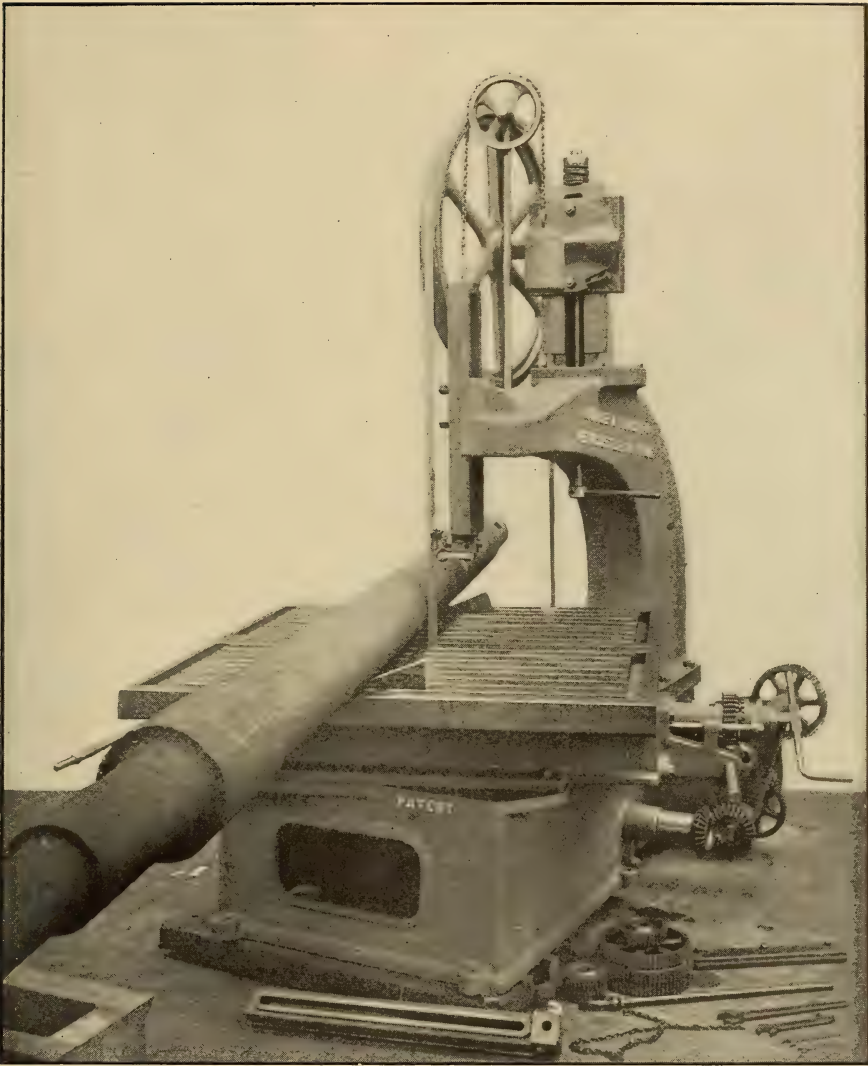
SAWING MACHINE WITH 60-INCH BAND, FOR STEEL PLATES. CLIFTON & WADDELL, JOHNSTONE

blades may be used at option, it is capable of doing an infinite number of jobs which are now done on milling machines and slotting machines.

The heavy hack-sawing machine made by Holroyds has compound slides to carry the saw, and has embodied in it the principle of rotating the bar to expedite the cutting and obtain a true, square face. The machine illustrated uses a blade 23 inches long, will cut bars up to 10 inches diameter, and weighs 3,500 pounds. The general design embraces

by a pawl fastened in a reciprocating frame and operated from a roller attached to the horizontal slide. This runs in an inclined slot, which is part of the rocking frame.

The band-sawing machine is better known for woodworking than for metal, but a very large number of metal band-saws are in daily use engaged on rough forgings, ripping off surplus material, plate and girder work, and all kinds of curved work. They effect an economy in power over the circular saw, and work more

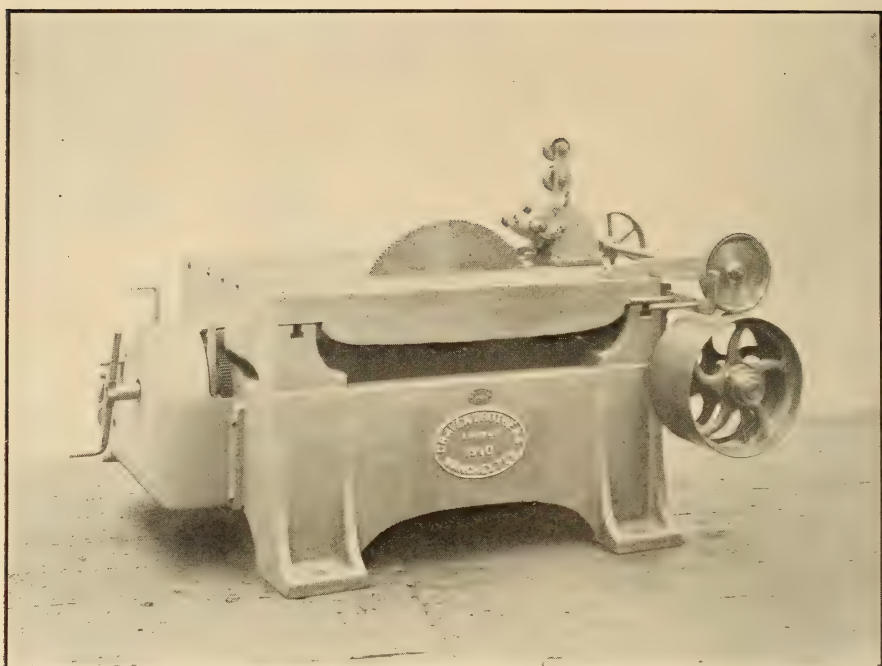


BAND SAWING MACHINE. MESSRS. NOBLE & LUND, LTD., NEWCASTLE-ON-TYNE

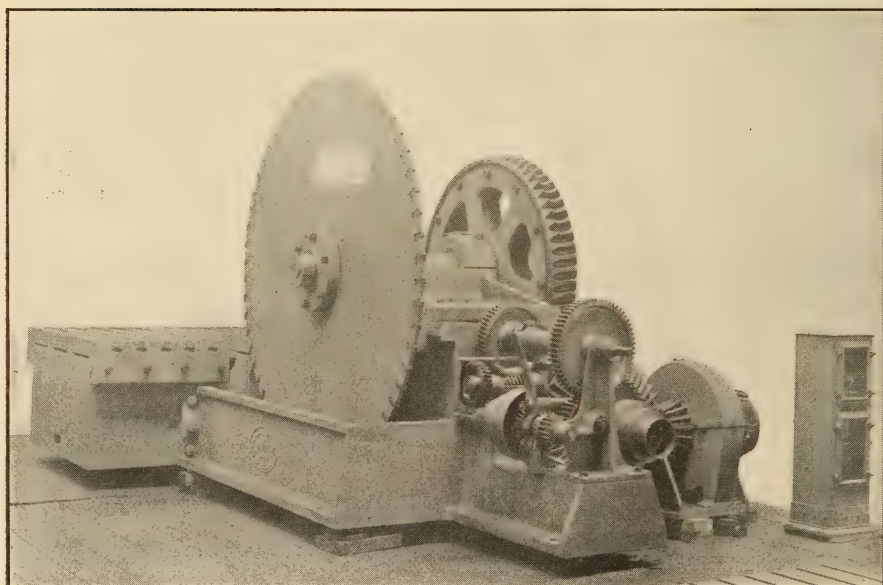
silent and smoother. Of all sawing machines, the band-saws of different makers vary least in design. The general construction is a strong main frame with a self-acting table and an overhanging arm carrying the upper saw pulley. This upper pulley is carried in a vertical slide, so that it may be adjusted to suit varying lengths of saws and maintain the requisite tension on the saw. The bearing for this pulley is also usually made so that it can swivel to

enable the saw to run on any desired part of the rim and quite true. Both the top and bottom pulleys are covered with rubber, to make an elastic cushion for the saw, and to create sufficient friction for driving. The lower pulley usually runs in a trough of soapy water.

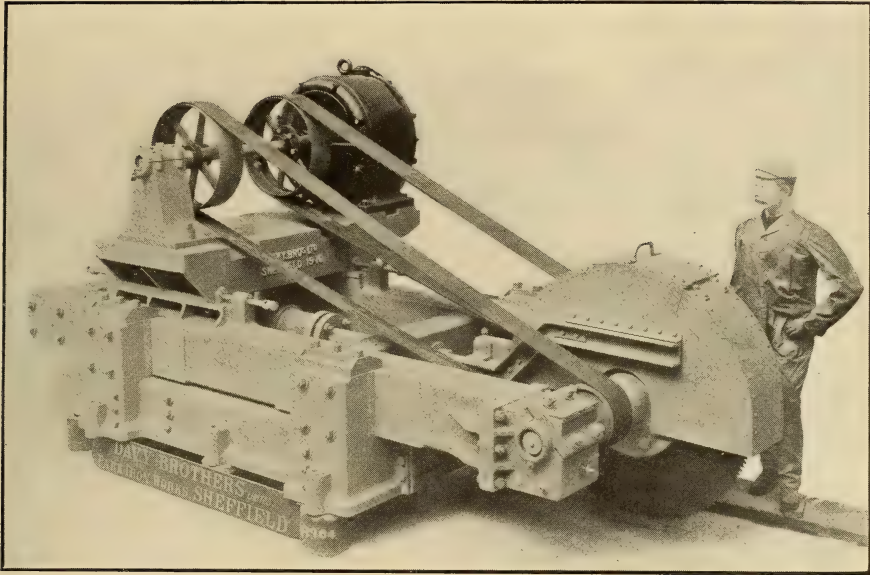
Frequently band-saws are made with three pulleys, so as to allow a long reach of the overhanging arm to deal with very wide plates. One of our illustrations shows such a ma-



SAWING MACHINE WITH BOX TABLE, 24 INCH. CRAVEN BROS., LTD., MANCHESTER



EIGHT-FOOT SAWING MACHINE. MESSRS. CRAVEN BROS., LTD., MANCHESTER



HOT SAWING MACHINE. DAVY BROS., LTD., SHEFFIELD

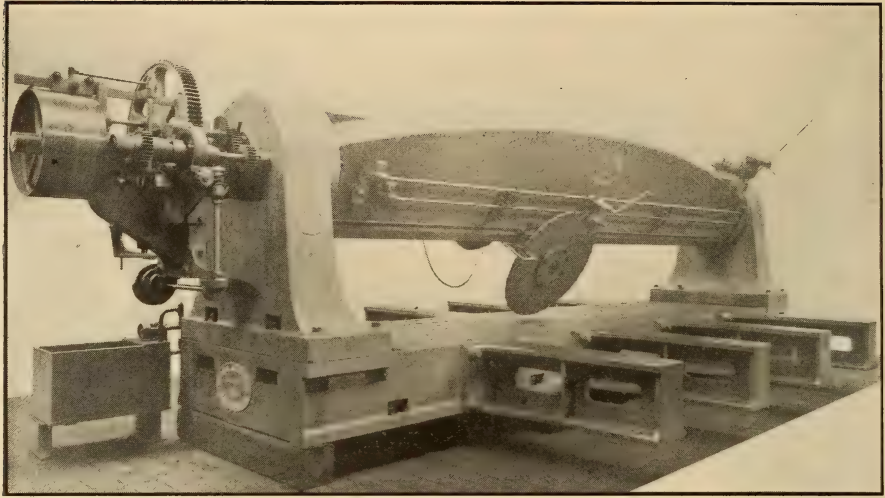
chine as made by Messrs. Clifton & Waddell. This is also fitted with a feed gear box to give instantaneous change of feeds without stopping the machine, and is a distinct improvement over the ordinary method in use on band-sawing machines of change wheels and a swing plate.

The cutting of steel by high-speed revolving discs of mild steel has been greatly developed during the past few years, and is generally acknowledged to be the most rapid and efficient method known. Its use has proved most valuable in steel works where a large tonnage output is essential; as, for instance, a heavy channel section of 12 x 6 x $\frac{3}{4}$ -inch metal can be cut through in about 15 seconds. The disc used in these toothless sawing machines is of mild steel, preferably of boiler-plate quality about $\frac{1}{4}$ inch thick, and runs at a periphery speed of 20,000 feet per minute. As may be understood, plenty of power is required for these machines, but this is considered the cheapest item in a large works; also, less power is absorbed by using a motor of 100 horse-power to cut through a given section of steel in

30 seconds than to use a motor of 50 horse-power and take 60 seconds or more to do the same work. The wear of the disc is also less. About 10 horse-power is used to drive the machine without doing any work.

The rate of traverse varies according to the thickness of the work, but for cutting girders, channels, etc., a good rate of traverse is 1 inch per second. Messrs. Clifton & Baird, of Johnstone, use a hydraulic ram to effect the traverse of the disc carriage on their patented machine. This is controlled by a hand lever, and gives a quick return. The work is stationary, and does not require clamping down.

Toothless saws have been in use cutting armour plate for a number of years. The theory of the action is abrasion by local fusion, due to the very high speed of the disc, causing so many thousand inches of surface to impinge on the metal undercut that the material acted upon is heated at the point of contact to a temperature approaching, if not equal to, the fusing point. It appears as if a very small portion of the metal being cut immediately in the neigh-



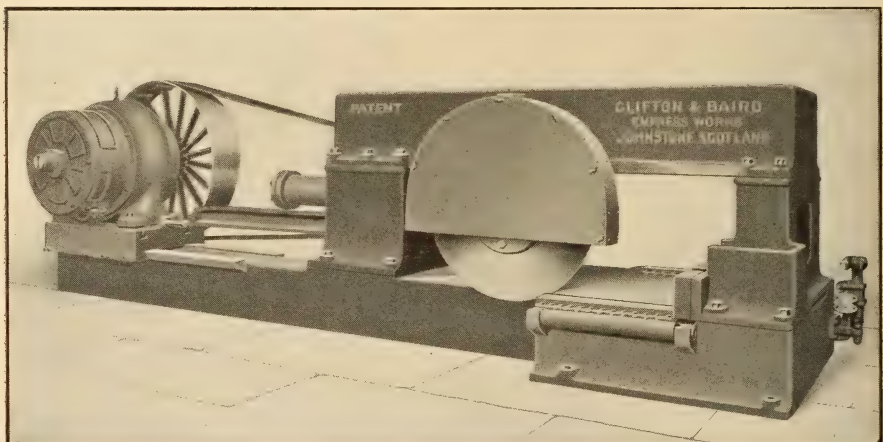
BEAM SAWING MACHINE FOR SAWING ARMOUR PLATES SQUARE OR AT ANY ANGLE. CRAVEN BROS., LTD., MANCHESTER

bourhood of the point of contact is first melted and at once rubbed off, thus exposing a fresh surface to the frictional action, and that this process goes on continuously while the disc is working. The temperature of the disc must necessarily be much lower than the work in contact with it, owing to its large surface area, and when it is considered that all the frictional energy of the rotating disc is concentrated on an extremely small area of contact in the material subjected to its action the results ob-

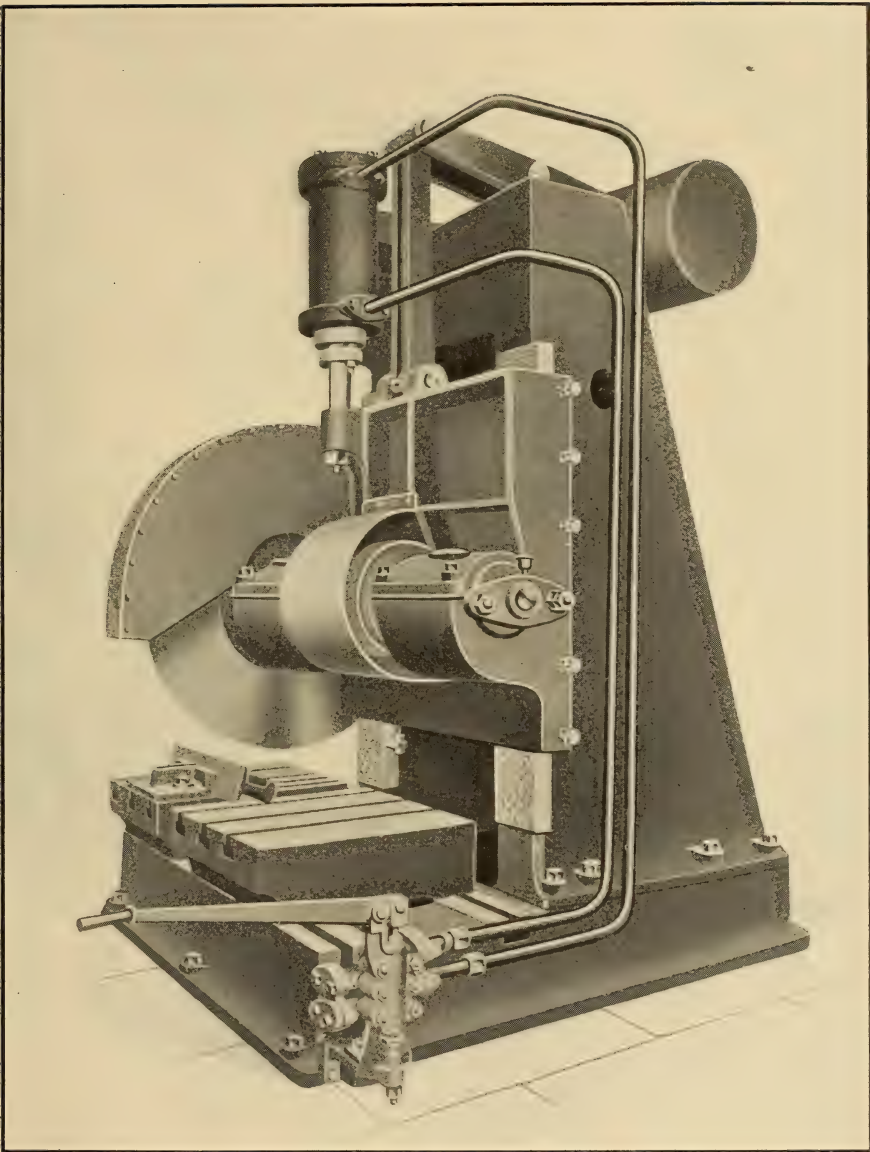
tained are not so surprising as appear at first sight.

The reason why hard or high-carbon steel can be cut more satisfactorily than mild steel or wrought iron is because the fusing point or melting temperature of hard steel is lower than that of low-carbon steel and wrought iron. The converse reason explains why hard steel discs are not so good as soft steel ones.

When the disc is in good order cuts can be made almost as smooth as glass and perfectly square; a pin



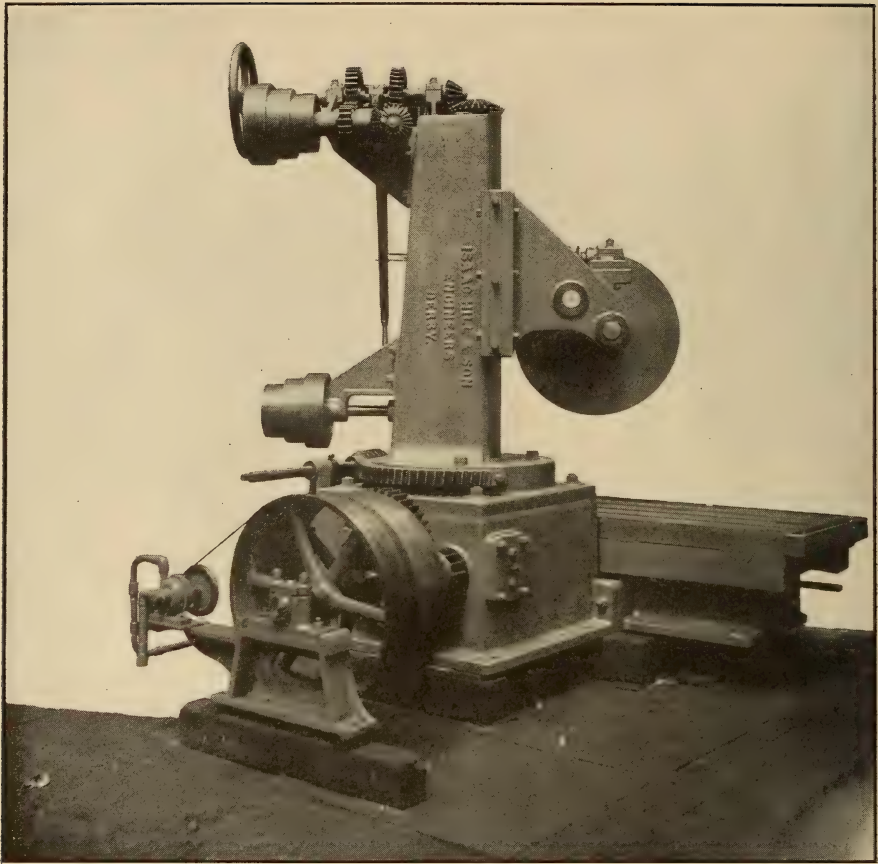
DISC SAWING MACHINE. CLIFTON & BAIRD, JOHNSTONE



DISC SAWING MACHINE. CLIFTON & BAIRD, JOHNSTONE, SCOTLAND

is always left on the under side of the work, but these pins are easily broken off by a hammer blow, owing to being tempered under the action of the heat and the water used in cooling. The work is usually cut through so quickly that the heat generated in the path of the disc has not time to spread into the work, the sides of the cut only being warm.

Although this type of machine is so well adapted for a large tonnage output in steel works, a word of caution is necessary, because it does not compete with cold saws for finished work, and it is well for anyone interested to consult a specialist before laying down a disc sawing plant. A machine that is a great money saver on one class of work



VERTICAL METAL SAWING MACHINE WITH SWIVELLING HEAD AND CENTRIFUGAL CIRCULATING PUMP.
ISAAC HILL & SON, DERBY

may be merely a white elephant in another class.

In steel works and rolling mills it is often necessary to cut steel blooms or ingots and rails while in a very hot state, and for such work the saws usually run at a very high periphery speed, usually about 15,000 feet per minute. The rate of traverse necessarily varies with the section being cut. For cutting light sections such as angles and joists, the traverse goes up to about 1 foot per second; but for cutting solid bars the traverse is proportionately slower, de-

pending on the thickness of the section, and also, to some extent, on the temperature. For instance, an 8-inch x 8-inch bloom can be cut through in about $\frac{1}{2}$ minute.

Two types of machines have been selected for illustration, and in both hydraulic power is the means provided to feed the saw into the work; and it will be noticed that the construction throughout is massive. In both cases two belts are used for driving, one on either side of the saw blade, to ensure equal driving and absolute steadiness in running.

ENGINEERING AND AGRICULTURE

HOW THE COMPETITION BETWEEN CANADA AND THE UNITED STATES IS
AFFECTED BY MODERN MECHANICAL APPLIANCES

By A. W. Day

With the increasing closeness of commercial relations between Canada and the United States, due both to international agreements and to the natural development of the productive resources of the Dominion and the Republic, the extent to which mechanical appliances will affect the result becomes of interest. Under any reciprocity arrangement it is extremely probable that Canada will become a wider market for agricultural machinery, while the United States will at the same time receive a very great portion of the products resulting from the operation of that machinery. The present article treats of this timely question from both viewpoints, and shows the manner in which engineering methods must inevitably dominate the situation.—THE EDITOR.

THERE is probably no department of industry in which the use of power-operated machinery for the saving of time and labour and for the increase of capacity and output has been less evident than in agriculture. Compare the production of the raw material of foodstuffs with the manufacture of lumber, steel, textiles, and even building materials, and the difference in the utilization of power instantly appears. In the improvement of harbours and waterways, as well as in the operations of land drainage, the heavily-powered dredges and excavators are everywhere in evidence, supplemented by locomotives, cars and track.

We now have two great agricultural countries, neighbours and competitors, rapidly becoming alive to the tremendous possibilities of a wider use of power machinery in their fundamental development, in the production of the food by which not only their own people but a large part of the rest of the world are to be sustained.

In the United States the farming area occupied at the present time comprises nearly 315,000 square miles, or about two hundred million acres, and, in view of these figures, it seems almost incredible that the importance of power-operated machinery as an economical factor in agriculture has not been more fully realized. It is true that the records of the Department of Agriculture show that mod-

ern improved mechanism is in operation on about eight million acres of cultivated soil, but this means only about 4 per cent. of the farming territory actually devoted to crop production. The figures show that the remainder of this immense area is still cultivated by the use of mechanical appliances such as the plow, harrow, rake and harvester, but operated, not by mechanical power, but by the horse, the mule, and sometimes even by manual effort.

When the results which have been accomplished by the introduction of machinery operated by steam, gasoline or electric power are considered, it will be fully demonstrated that, even allowing for greater first cost for supplies and for repairs, the increase in capacity is so great as to warrant the statement that one of the greatest of national wastes is that due to the tillage of the fields by the old-fashioned methods.

Abundant data are available to prove this assertion, for tests have been made, especially on the larger farms of the Western States, and also on the famous tule lands of California, which show the great economy and capacity of steam power when applied to farm engine or tractor. Since the tractor was placed in active service on the farm in 1900 its numbers have increased until at the present time nearly 10,000 are in service, varying in horse-power according to the work required. The reason for its popularity is that the



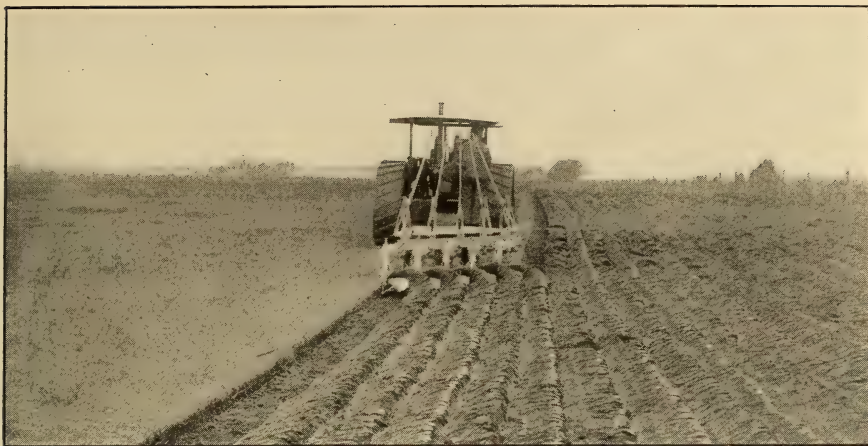
THE MODERN WAY OF TURNING UP THE SOIL. MOTOR DRAWING FIVE CIRCULAR PLOWS IN HEAVY SOIL

tractor is adapted for such a variety of purposes. In the plowing and cultivation of heavy lands, such as clay soil, and the black muck so abundant in the West, and the stiff, sod-covered prairie, the portable en-

gine can turn up the earth, drawing a series of plows where four horses could not pull even one implement. The daily result in acres is, of course, determined by the power employed. The theoretical plowing capacity of



PLOWING HEAVY PRAIRIE LAND WITH A GASOLINE TRACTOR

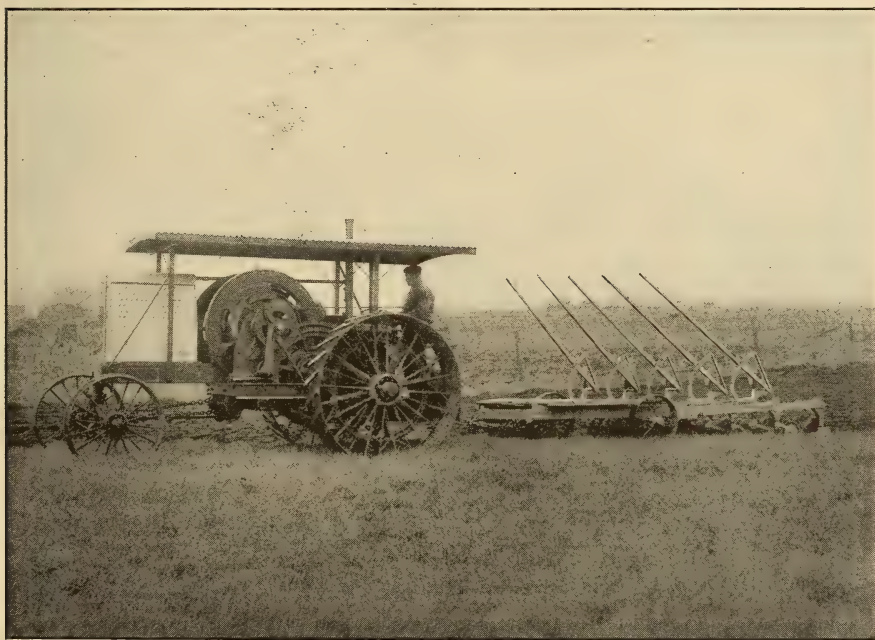


PLOWING A TEN-FOOT SPACE AT A TIME

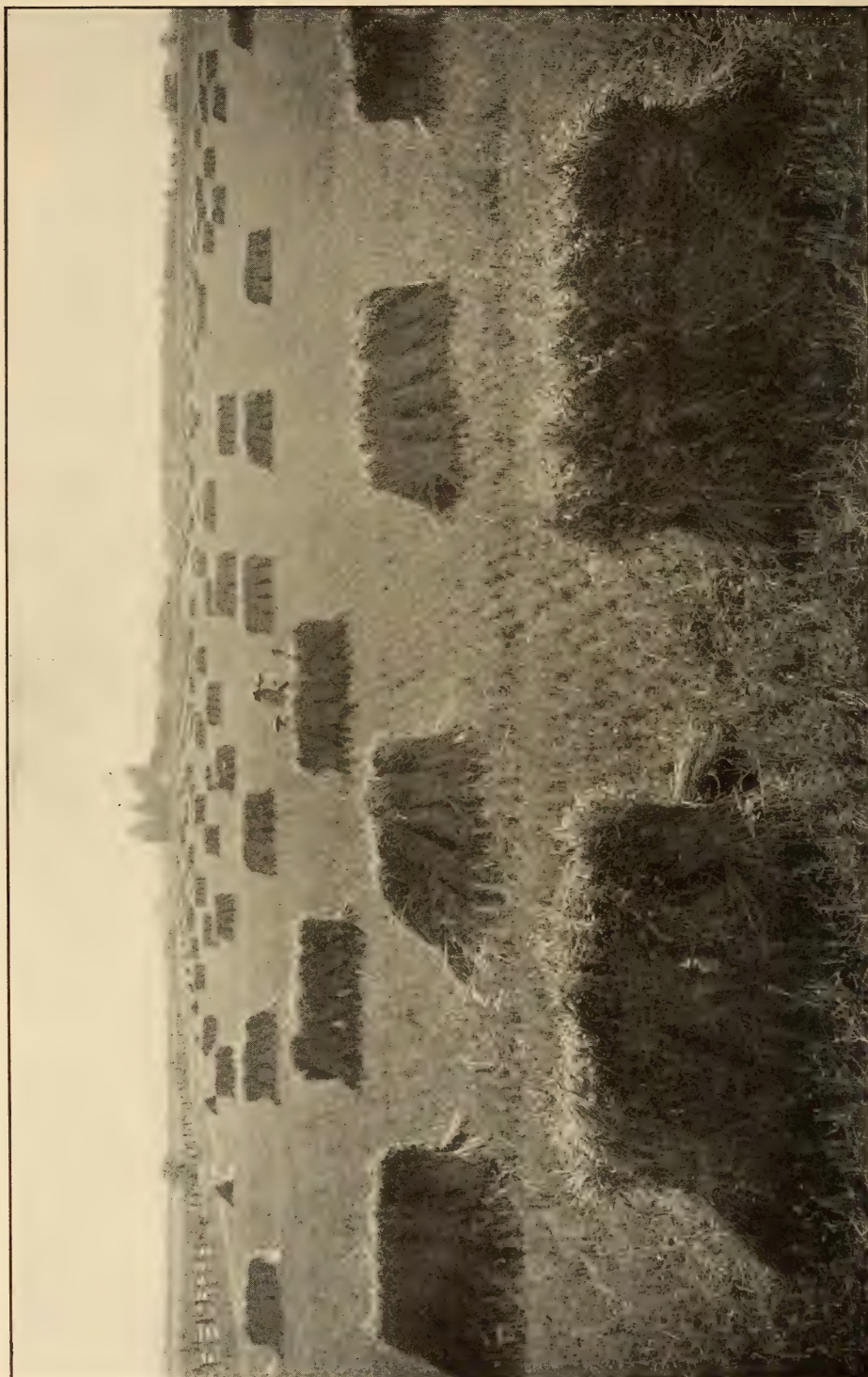
the steam plow is thirty-eight acres a day for the moldboard plow and forty-five acres for the disk, the day being twelve hours long. The daily actual average, as gained from reports made by plow owners, is twenty-three acres for moldboard plows in the Northwest and twenty-six acres for the disk plows in the

Southwest. The moldboard plow is used almost exclusively in the Northwest and the disk in the Southwest.

As to the service performed, steam engines used for plowing are usually rated at from 20 to 50 horse-power, from 25 to 35 being the figures usually. The steam plowing engines weigh from 7 to 20 tons, and cost



A GASOLINE TRACTOR OUTFIT



A WHEAT FARM IN CANADIAN FOOT-HILLS

from \$1,500 to \$3,000. On the Pacific Coast the usual engine is larger, averaging about 60 horsepower and costing from \$5,000 to \$6,000. The average cost of the miscellaneous equipment for the steam plowing outfit adds another \$500 to the investment. In California some of the owners of large outfits plowing nearly 3,500 acres annually each estimate the average durability of the outfit at fifteen years, or more than 50,000 acres per plow, in addition to threshing and other work done outside of plowing seasons. A crew of from three to six men is needed to operate a large steam plow. One is the engineer, whose pay ranges from \$3 to \$4.75 per day; one guides the engine, one fires, one looks after the plows, one drives the team that keeps the engine supplied with water and fuel, and, in many cases, a cook also is carried. The prices charged by traction plowing outfits range from 75 cents to \$5 per acre. The lowest fig-

ures usually are for stubble plowing and the highest for breaking sod. The acre-cost of steam plowing, as found by a comprehensive investigation, is from 75 cents to \$1.85—less than one-fifth of the cost where the horse and mule are employed.

The plains of western Canada have recently developed into wheat fields by this aid. In 1900, about the time the tractor plow became unquestionably practical, there were fewer than 2,500,000 acres sown to wheat between Winnipeg and the mountains. In 1909 Saskatchewan alone had 4,085,000 acres sown to wheat, which yielded 90,255,000 bushels, or more than Manitoba and Alberta combined. Manitoba had 2,643,111 acres, which yielded 45,774,707 bushels, and Alberta 333,000 acres, which yielded 8,250,000 bushels. These three provinces combined thus had 7,058,111 acres, which yielded a total of 114,279,707 bushels, or more wheat in one year than the entire German Empire.



DIFFICULT WORK IN A MANITOBA WHEAT FIELD



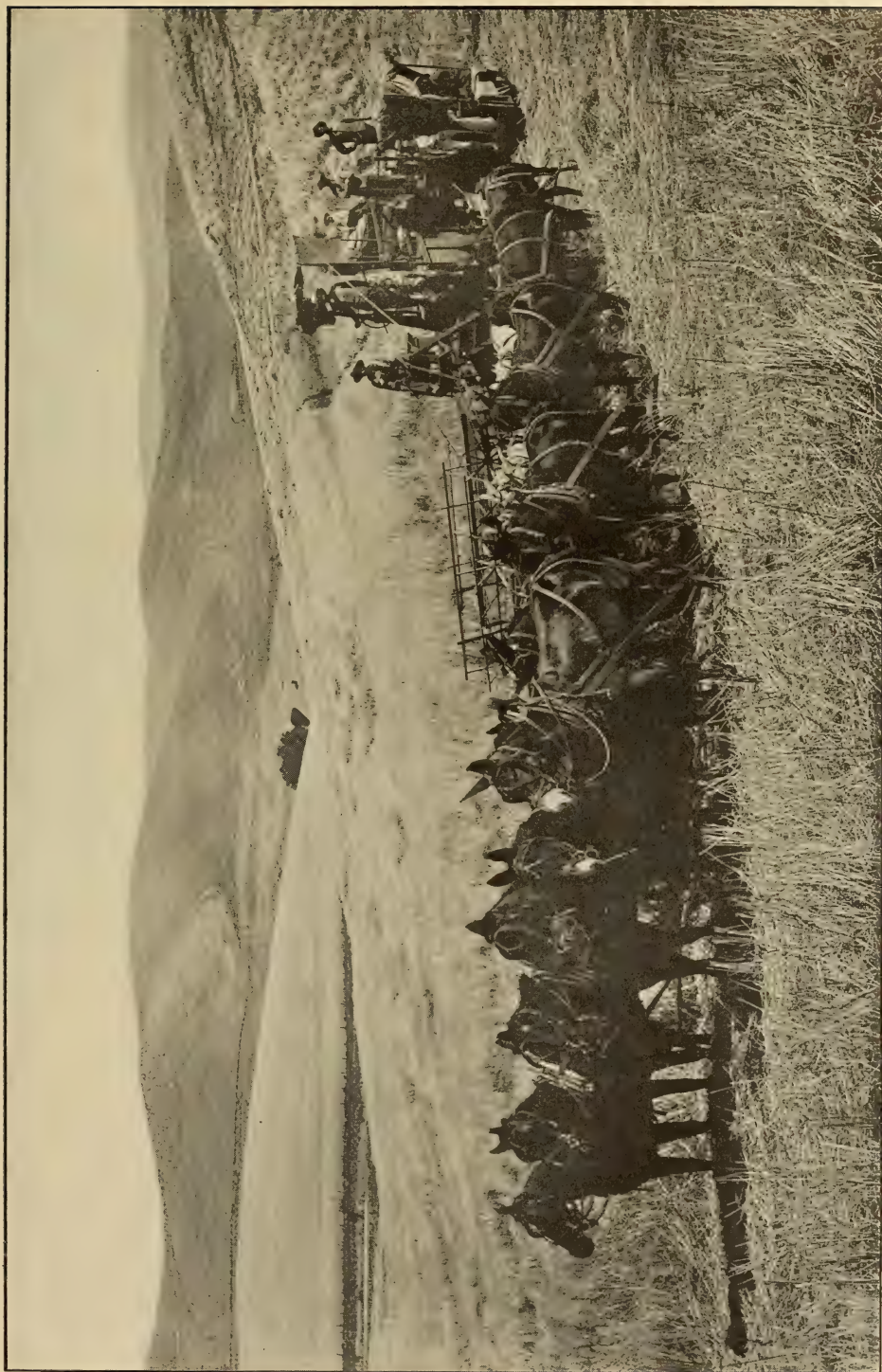
THE OLD WAY OF HARVESTING WHEAT BY HAND. ON THIS FARM MC CORMICK DEVELOPED THE REAPER

These great tracts of Canada have demonstrated not merely the importance, but the necessity, of power mechanism. Grain is grown on what

was formerly prairie land, which is very tenacious and of hard composition. Here and there are fields covering several hundred acres, while



HARVESTING WHEAT ON A LARGE WESTERN FARM AND THRESHING THE GRAIN AS IT IS CUT



A COMBINED HARVESTER OF THE TYPE USED IN THE SASKATCHEWAN TERRITORY



CUTTING WHEAT ON A HUNDRED-ACRE FIELD IN EASTERN OREGON

hundred-acre fields are numerous. It would be impossible to plow, cultivate and harvest these, even by horse-power, except at a great loss in time and expense to the farming community. Here is an illustration in point. In Saskatchewan, a section of rich, wild sod land, 640 acres, was broken in twenty-two hours, three steam outfits working continuously in order to get the land plowed immediately. A six-horse team, with a gang plow, would have required a month, Sundays included, to perform the same amount of work. The result was that the owner was able to plant his entire 640 acres at the right time, instead of only a small portion of it, as would have been the case had he depended upon animal power.

Several types of tractors are in use for agriculture. One design, employed in California, is noted for its dimensions and performance. The largest size has driving wheels 8 feet in diameter, with 60 inches face of tire. The lead wheel is 5 feet in diameter with 48 inches of face, which gives a tremendous bearing surface, enabling the engine to go over very soft ground. This engine develops 110 horse-power on the crankshaft,

and can pull six gangs of plows, cutting a furrow each time of about 36 feet in width, and traveling at the rate of 3 miles per hour. It will also haul a steam combined harvester, clearing a swath 35 feet in width. It cuts, threshes, recleans and sacks the grain from 100 to 125 acres each day at a cost not exceeding 30 cents per acre. A smaller size, used for hauling supplies and wagons, has a capacity of 50 tons, depending upon the conditions to overcome. The speed of the engines is 3 miles per hour, with or without a load, which is as fast as deemed practicable to run machinery of this class over ordinary country roads.

This engine, by the Best Manufacturing Company, is a Western design, and intended for the soft, loose tule lands, its broad wheel tires preventing it from sinking into the earth and lessening its traction.

Another Western tractor, also illustrated, is the Holt, which is manufactured on the Pacific Coast. It is intended not only for agriculture, but for hauling farm and freight wagons on the rough and heavy-grade mountain roads. Loads too heavy to be hauled easily by the ordinary six and

eight-horse freight teams can be removed by the traction-engine freighting outfit expeditiously and economically. They will do heavy hauling for less than half what it costs to do the same work with horses, or, up to 100 tons per day, will do the work for less than it could be done by means of railroads, as tests have shown.

This tractor has an engine of 60 horse-power and main wheels 7 feet 6 inches in diameter, driven independently by chains and friction gear, dispensing with any equalizing gear. The use of main and secondary chain gear permits a broken link to be readily replaced in case of breakage—an important matter in the field or on the road. An auxiliary wagon, with an engine which can take steam from the main boiler and be connected to the traction by chain and clutch gear, is used to increase the tractive power for steep grades and extra heavy loads. These engines are arranged to use oil fuel, as especially adapted for the locality and conditions for which they are

most used, or, by a modification of the grate, they may be used for either coal or wood fuel.

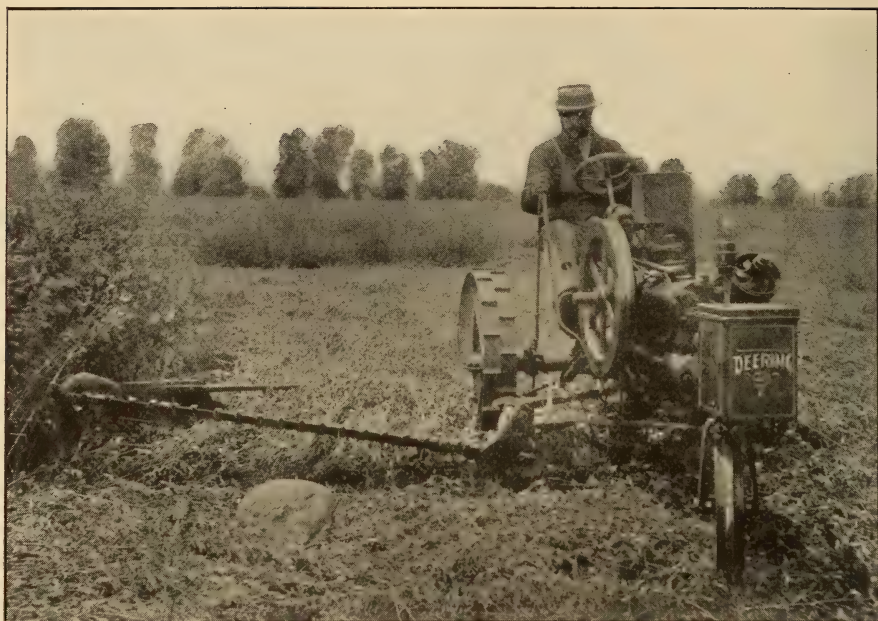
These engines will haul a load of from 40 to 60 tons, depending on the character of the road, at a speed of from 2 to 3 miles per hour, loaded, and to 4 miles, empty, ascending with a full load, on good roads, grades up to 10 per cent., smaller roads on proportionately steeper grades.

For the small farm, ranging from 50 to 200 acres, the tractor, if driven by a gasoline engine, is an economical and really necessary source of power, since it is self-propelled and can be utilized in so many different agricultural processes. This type of tractor, designed by the experts of the International Harvester Company, makes a new era in power application to agriculture, and is already in service both in America and in Europe. Its advantages over steam power include higher efficiency, economy and convenience.

One manufacturer builds three types of the vapour-driven tractors, ranging from 12 to 20 horse-power.



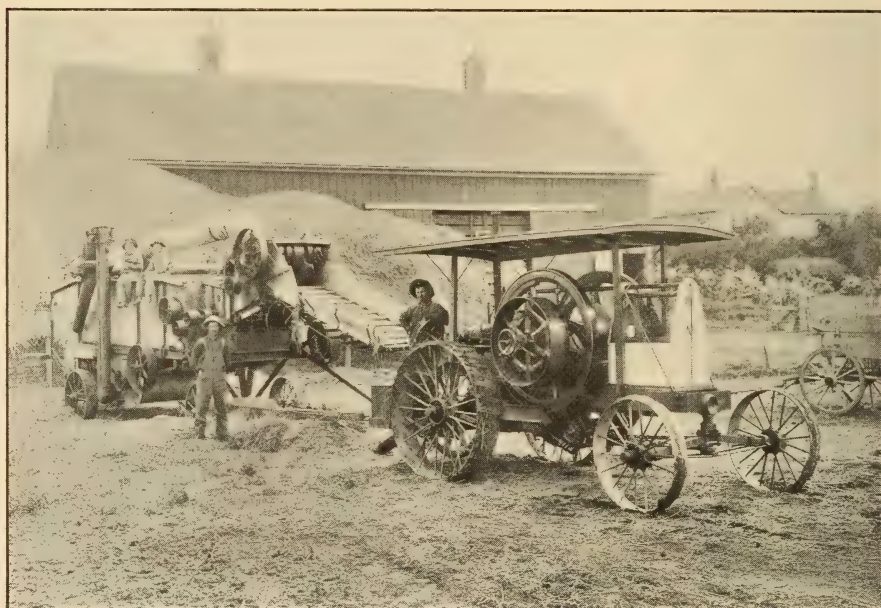
HARVESTING WHEAT, SHOULDER HIGH, IN THE IMPERIAL VALLEY



A GASOLINE-DRIVEN MOWING MACHINE

A brief description of the smallest gives an idea of what gasoline power means to the farmer in efficiency and economy. The engine is a regular

12 horse-power engine mounted on two channel-steel sills of great strength and durability. To this main frame is bolted the sub-frame.



THIS GASOLINE ENGINE THRESHES THE GRAIN AND STORES THE STRAW AND KERNELS WITHOUT A HUMAN HAND TOUCHING THEM



GASOLINE DRIVEN PUMPS USED FOR SPRAYING ORCHARDS AND KILLING DESTRUCTIVE INSECTS

reinforced by two angles to make the frame rigid and prevent twisting, and also to keep all gears and boxes in accurate alignment. At the front end of the main frame is the bolster, which connects with the front axle by means of a ball and socket. The axle is arched, and is provided with very substantial truss rods, making it capable of withstanding any twisting or jarring to which it may be subjected. The driving wheels are 56 inches in diameter and have a 16-inch face. To this 16-inch face are riveted cleats, which provide ample traction when going through mud or over soft ground. Extra mud legs are also provided, to be used when working under extremely bad conditions.

The power is transmitted from the engine crankshaft to the drive wheels by only two sets of pinions and gears. The two speeds are obtained by two gears on the clutch sleeve located on the engine crankshaft. When using the slow speed, the smaller

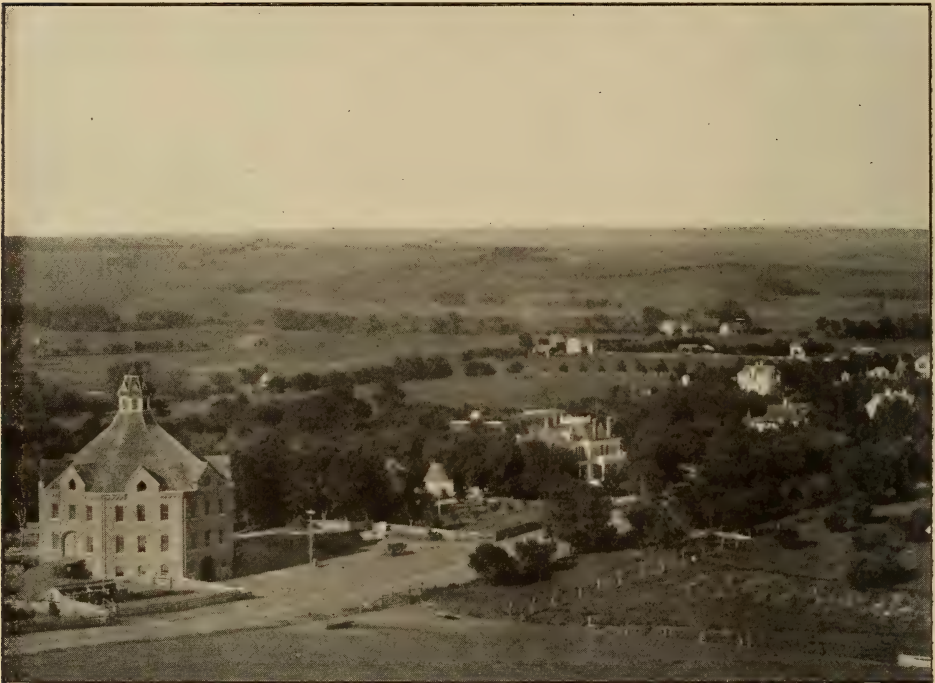
gear is selected and moved into the mesh with the larger gear on the countershaft. To obtain the fast speed, the small gear is moved out of mesh and the large gear is moved into mesh with the smaller gear on the countershaft. The gears are controlled by hand levers, and are provided with notches to hold each gear in its respective place. It is impossible to have two speeds in mesh at one time. These gears are also so arranged that, when the engine is doing belt work, all of the gears may be thrown out of mesh. They then revolve as idle gears with the engine. The reverse is accomplished by means of a friction gear, which is mounted on a hollow eccentric.

This tractor is adapted for all light work, such as found on the average small farm. It will draw two or three plows. It proves satisfactory for operating small threshing machines, shredders, huskers, shellers, and many other machines. The second speed with which it is provided

permits the tractor to move these machines at the same speed as would a team of horses. It is especially adapted for hauling purposes and drawing binders. The friction clutch is smaller in diameter than the regular friction pulley on the opposite side of the engine, so that when this friction clutch is used as a belt pulley the tractor is actually provided with two pulleys of different diameter,

necessary implements. The gasoline tractor is another revolution in power application that is of great importance in the agriculture of the future.

The greatest invention to further agricultural progress and prosperity has been the evolution of the harvester, now to be seen in the grain fields throughout the world. From the days of the McCormick, the

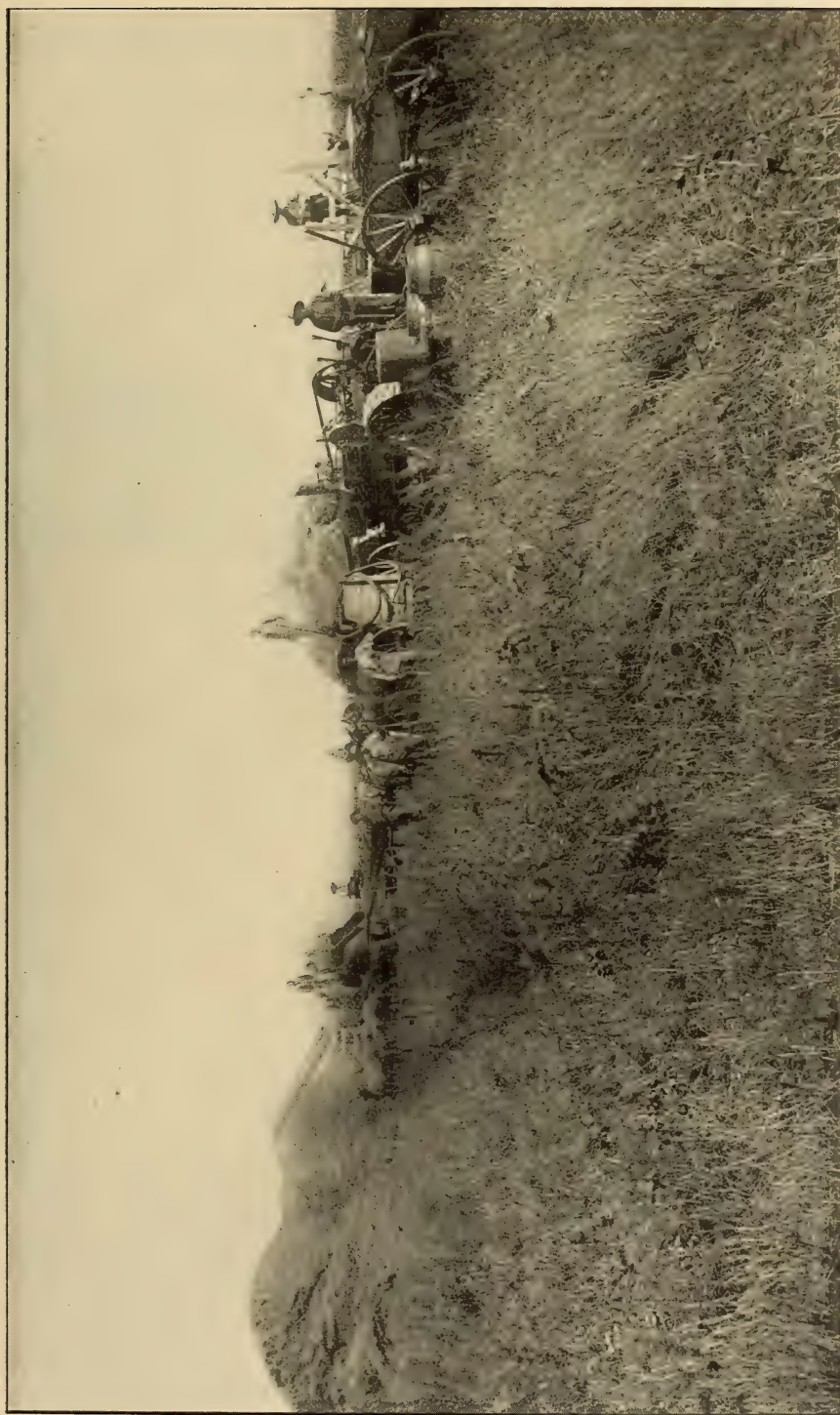


A FARM VILLAGE OWNED BY ONE MAN. THE HOME OF THE GREATEST CORN RAISER IN THE WORLD, AND IN THE STATE OF MISSOURI. EVERY BUILDING IS A PART OF THE FARM

both of which may be used at one time.

The capacity of the 20 horse-power tractor is best shown by the discovery that, when in service, it develops enough power to haul four 16-inch plows or a load of $6\frac{1}{2}$ tons; but, like the others, it can be employed for many other operations on a farm, even to operating the cream separators in the dairy, churning the butter, and cutting the hay and corn for ensilage, when attached to the

genius who first conceived it, the changes in the mechanism have indeed been remarkable. Ten years elapsed before the farmers who studied McCormick's idea were convinced that it was practical, such was the prejudice inspired by ignorance of the soil tillers. To-day more than 400,000 machines, representing several types of horse harvesters, are in use, in addition to composite machines hauled and operated by the tractor, which furnishes power not



THRESHING MACHINERY IN AN OKLAHOMA WHEAT FIELD



THRESHING WITH AMERICAN MACHINERY IN RUSSIA

merely for cutting the wheat crop, but for storing it in the receiving wagons, operating the thresher, and also the machinery which bags the grain for storage, a crew of only three men being needed besides the engineer. The harvester alone does the work of twenty men.

The separate threshing machine driven by belting from the portable steam engine is still a familiar sight in the wheat fields of the smaller farms in the Middle and Central Western States; but with the opening of the huge wheat ranches of the West there has been developed and brought to a very practical standard a combined harvester and threshing machine. These machines cut, thresh and sack the grain at one operation. As they travel through the field, one sees the cutting bar, 15 to 25 feet in length, slicing its way through the standing grain, and, on the other side, he witnesses the steady delivery of the grain in sacks ready to be hauled to the railway elevator. The cutting bar is 25 feet long, the separator or thresher measures 54 inches, and has

a capacity for cutting and threshing 65 to 100 acres of wheat per day, the amount depending upon the condition of the grain to be harvested.

As a matter of comparison between the power-propelled and the horse-drawn machines, it may be noted that the cutting bar of the horse-hauled harvester is 16 feet long and the thresher measures 36 inches, and it can cut from 35 to 40 acres per day.

The harvesting expenses, when using the steam harvester, are from 35 cents to 50 cents per acre, while the horse-drawn machine operates at an expense of from 50 to 70 cents per acre.

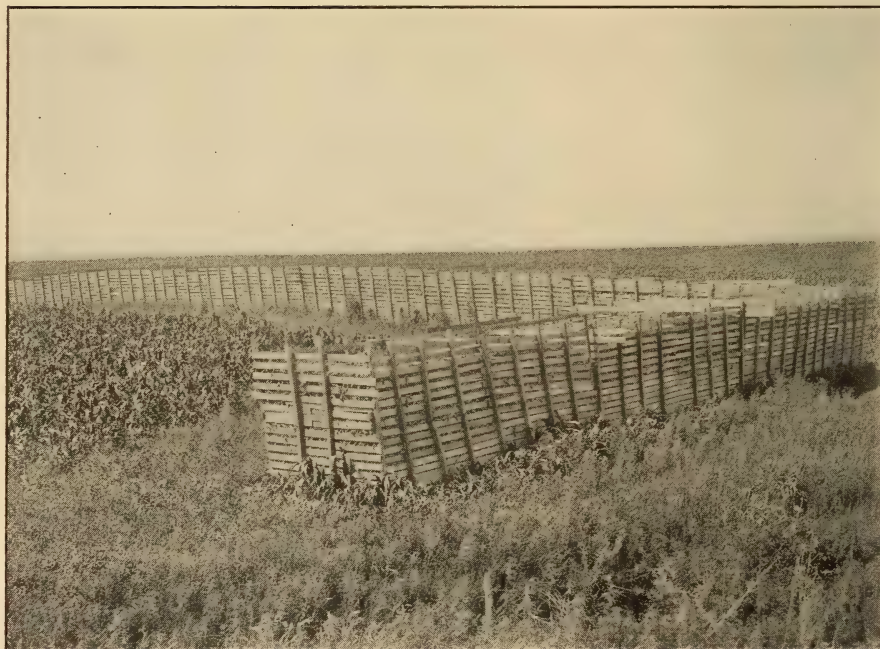
Relative to the early importance of grass-cutting and grain-reaping machinery, in 1840 there were three reapers made, and less than that number of people were employed upon them. In 1845 fifty people were employed in the manufacture of 500 machines. In 1850 the production had increased to 3,000, and in 1860 20,000 machines were produced, in the manufacture of which 2,000 peo-



POWER STACKING MACHINERY IN THE HAY FIELD



MR. RANKIN BOSSING THE WORK ON HIS 40,000 ACRE FARM

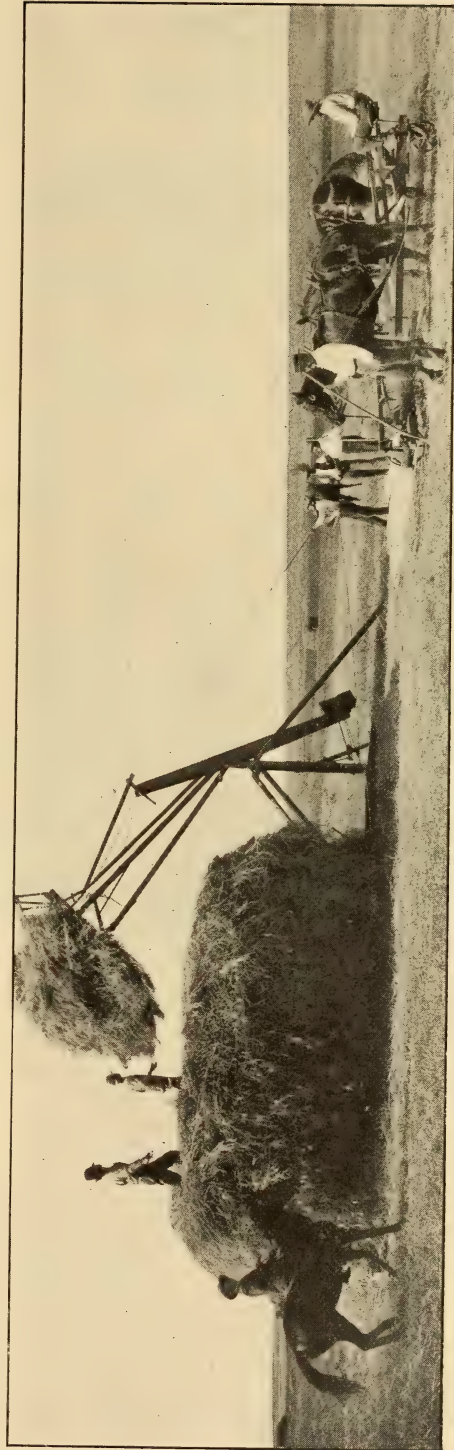


ONE OF THE RANKIN CORN BINS, LOCATED IN A CORN FIELD. THIS HOLDS 12,000 BUSHEL

ple were employed. About the year 1880, shortly after the automatic cord binder was perfected, there was an immediate and marked increase in the output. In 1885 more than 100,000 self-binding harvesters were sold, in addition to no less than 150,000 reapers and mowers, 20,000 hands being engaged in their production.

This advance in the farm-machine industry seems remarkable; but the increased output has been far from keeping pace with settlement of vacant farm land, especially in the States west of the Mississippi river. While the steam and gasoline tractor are associated with modern agriculture, the inventor has also greatly improved other devices needed for farm work. The modern threshing machine is equipped with an automatic band cutter, self-feeder, automatic weighing and sacking device and pneumatic swinging straw stacker, the necessary power to operate all of these being either a gasoline or steam traction engine. By the old method of handling wheat the time required to produce a bushel was three hours. The modern harvesting machines reduces this time to ten minutes, the original cost being $17\frac{3}{4}$ cents per bushel, as compared with $3\frac{1}{2}$ cents per bushel now. The old threshing machine had a capacity of 175 to 225 bushels per day; the modern machines can handle 2,000 bushels and more in the same time.

A similar advance has been made in machines for handling the hay crop, by use of the self-dumping, sulky, steel hay-rake. This machine can be operated by a ten-year-old boy, who can do more and better work than could a man using the old method. The hay tedder enables the farmer to cure his hay quickly, and to improve greatly the quality of the hay. By means of the hay loader, timothy, clover or alfalfa can be taken direct from the swath and loaded on the wagon. With the modern sweep rake the hay can be taken direct from the swath or cock and



THIS HAY STACKER WILL LIFT A TWO-HORSE LOAD AT ONE TIME AND DEPOSIT IT UPON THE STACK

put into the stack with the hay stacker. Extensive use is also being made of the derrick hay fork, especially when the hay is to be put away in the mow.

In the modern methods connected with the corn harvest the old custom of pulling the ears from the stalks and leaving them to wither or rot in the field has been abandoned by the successful farmer, who makes valuable use of every part of the plant. The seed is planted by mechanism, which distributes it evenly throughout the field. The horse or motor-drawn cultivator replaces the hand hoe, doing the work far more thoroughly and more rapidly. When the crop is matured the modern corn binder cuts and binds the corn into bundles ready to be put in the shock. One man with a corn knife can cut about one acre of corn a day; the modern corn binder cuts and binds six to ten acres a day. The binding, husking, shredding of the stalk and putting it in the silo are done by machines that are driven by belting connections with the steam or gasoline engine. The silo, which may be large enough to hold 100 tons of stock feed, has a sheet-iron pipe extending from the top, ending in a movable joint. The upper part of the pipe opens to an exhaust fan. This fan, revolved from the same source of power, draws the ensilage through the pipe without the use of even a pitchfork.

Fertilizing a field by the older method is attended with much labour and needless expense, even where the farmer uses barn manure, which costs him nothing. If he follows the old way, the manure is slowly loaded into the wagon with the familiar pitchfork, slowly hauled to the field, while one man unloads the wagon and another spreads the fertilizer over the ground. A day may be required to cover an acre. If the back of the wagon was equipped with the device known as a manure-spreader, merely the pull of a lever

would set it in position, and, as the wagon moves along, the spreader would automatically cover the ground with an even depth of the manure, leaving no bare spots for the plants to spring up and die, as is so often the case where the pitchfork is used.

Late statistics of the manufacture of agricultural machinery show that the annual output in the United States has increased from a value of \$112,000,000 in 1905 to over \$130,000,000 at the present time. This indicates that the farmer who works with his head as well as his hands is rapidly increasing in numbers, and realizes the results he can attain by modern mechanical methods. There is no question that within ten years the farms all over the country will be far better equipped for the growing of larger crops to the acre at a far less expense than the cost of cultivating a smaller acreage largely by manual labour. Intensive farming is the cause of the farmers' success, and modern mechanism is an aid of vital importance in attaining success.

Ingenuity has been displayed in few inventions more notable than those which concern the soil and its products. The inventor has so reduced actual human labour in field and garden that a man can perform nearly every operation required by merely the turn of a wheel here and the pull of a lever there with one hand while he guides his horses with the other. He can actually plow, cultivate and seed 100 acres without walking a step, and, with his two or four horses and machine, will accomplish as much as a dozen or a score of men with hand tools. This accounts for the increase in the use of agricultural machinery, as proved by the statistics quoted.

When one stops to consider what these figures mean, he can get some conception of how machinery is aiding in the industrial revolution of agriculture. Invention has been stimulated by the demand for labour and time-saving appliances; but this

demand has originated from the desire of the agriculturist to apply methodical ideas, as in other channels of human activity. As he has studied his vocation, he has realized the great opportunities of which he can take advantage if he has adequate facilities.

If a man believes he can make a thousand or five thousand dollars more by adding to his acreage, he is strongly tempted to make the addition, especially when modern methods will give him the desired result without overwork. This is the secret of the expansion of many of the

Western farms to their present size, some aggregating 50,000 acres under cultivation. Not all their owners have succeeded, but many have done so, and the stories of the rural capitalists who direct operations from their automobiles and drive over their places behind teams of thoroughbreds, have more than a grain of truth in them, as the camera proves. But they are of the class who use their heads more than their hands, bearing the same relation to their property that the president of a cotton mill or of a foundry does to his industry.



THE RAILWAYS OF BRAZIL

XIII.—THE NORTHWESTERN RAILWAY OF BRAZIL

By *Lionel Wiener*

The present instalment of Mr. Wiener's study of the railway systems of the United States of Brazil is devoted to a very interesting line, notable both for its military significance, for the rapidity with which it has been built, and for the fact that it forms a portion of a scheme the completion of which will provide a transcontinental line from the Atlantic to the Pacific. In the next issue of this magazine Mr. Wiener will describe the railway system of the Rio Grande do Sul, with numerous illustrations, and close the series with a general review of the railway system of the country and its relations to the other nations by which the capital has chiefly been furnished and from which the greater part of the equipment has been purchased.—THE EDITOR.

THE North Western Railway is a long extension of the Sorocabana main line through the States of Sao Paulo and of Matto Grosso. Both roads are meter gauge throughout.

The situation of the North Western Railway towards the Sorocabana is similar to that of the Goyaz Railway in regard to the West-of-Minas Railway. It is, at present, more of a military line than anything else, its main object being to reach Corumba and the Bolivian frontier by the shortest possible route.

The Iguassu river, further south, had originally been deemed the best route; but the extension of the Sao Paulo Railways brought the Government to reconsider the original plans and to shift the origin of the line to Bauru.

But this decision had not been easily made. It should be borne in mind that the intervening land was totally unexplored, and that in any case the course of the railway was purely hypothetical. The object was the frontier of Bolivia, and the new line was to be as short as possible, that was all.

When, therefore, the Iguassu route was given up, it was in favour of a line from Uberaba, on the Mogyana's line north, to Cuyaba and the Rio Coxim.

This was given up, in turn, and the decree of 1904 changed the starting point to Bauru and the ter-

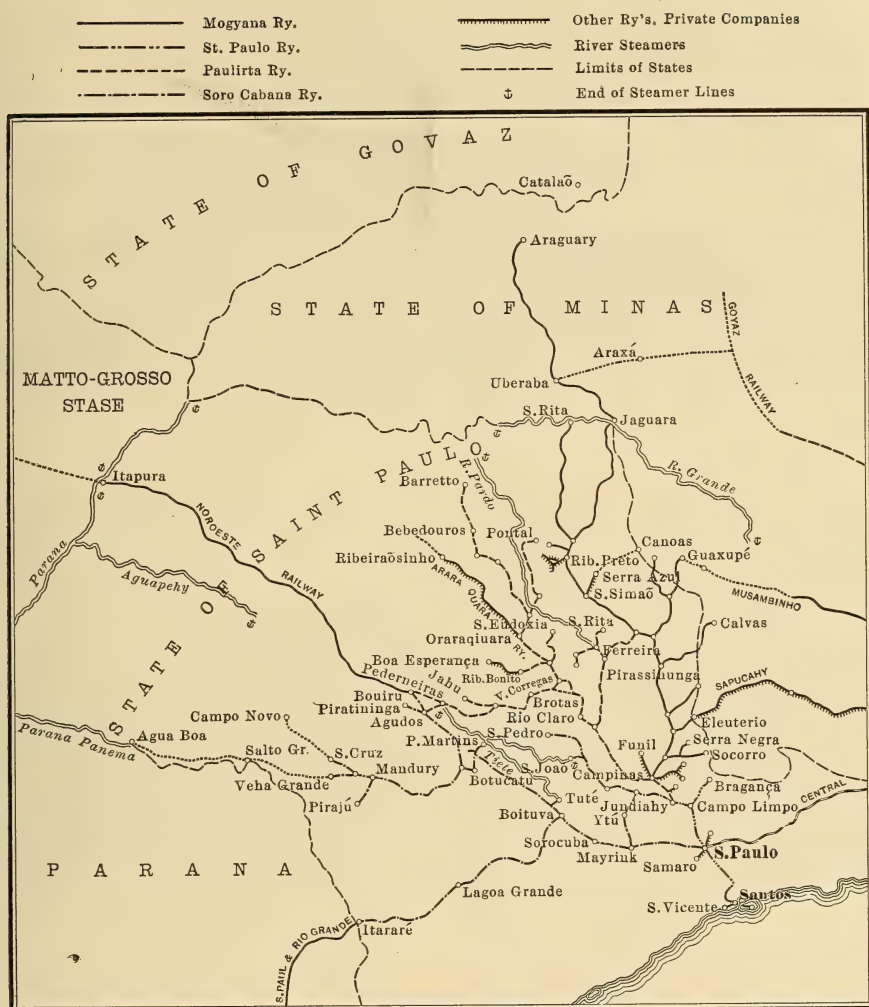
minal to the Bolivian frontier beyond Corumba. This had the advantage of avoiding the long stretch of Coxim marshes and of starting from Bauru, whence two railway lines, belonging—the one to the Sorocabana Company and the other to the Paulista Company, led to Sao Paulo and Santos. It is true the Paulista Railway did not quite reach Bauru, but of the two short-chord lines that were necessary to complete its road the first is already opened to traffic and the second will be opened in a few months.

This long line crosses the Parana river at Itapura, where rapids divide an upper from a lower navigable reach; then the Aquidauana and Miranda rivers, tributaries of the Paraguay and navigable to that stream, which the railway crosses at Esperança. It then runs up the further bank to Corumba and reaches the Bolivian frontier, five miles beyond, after having run due west, along the 20th degree of latitude, across an almost totally uninhabited country, with only three towns (by courtesy) to mark the line—Carpo Grande, Aquidauana and Miranda.

The importance of this line is considerable. Politically, it unites the furthestmost State with the centre of the Republic, and diverts through Brazil a considerable portion of the traffic for which the Argentine Republic has been catering. From a military viewpoint it provides a quick

THE RAILWAYS OF BRAZIL

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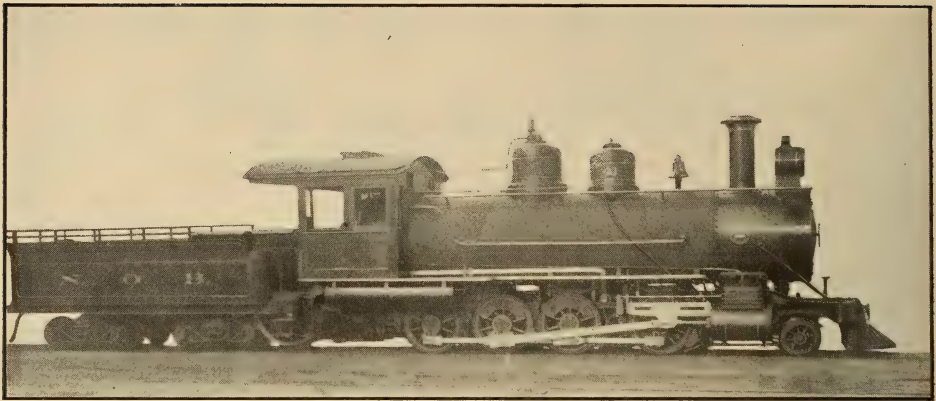


RAILWAYS IN WESTERN BRAZIL

route to the frontier; while considered as a railway, it represents the building of a line 915 miles long without any railway connection on the way, and that in a remarkably short space of time. It is hard to realize the difficulties of all kinds that had to be met and overcome across a country almost as unknown as Central Africa, where epidemics of malaria broke out frequently, and whose portion on the hitherside of Itapura is still infested with Red Indians, who kept on attacking the works.

The line was conceded to the North Western Railway Company, with a 6 per cent. guarantee of interest; but as the returns for the incompleted sections first opened to traffic were, naturally enough, purely nominal, the company met with considerable difficulty in raising the necessary funds for continuing construction work. Fearing work might stop altogether, the government therefore altered the original contract.

The company has retained the Bauru-Itapura section only, about



BALDWIN 4-6-0 LOCOMOTIVE FOR NORTH WESTERN RAILWAY

272 miles long, and divested itself of the remainder. As a compensation for this, the company has been granted the building of the latter portion, which always leaves a notable margin of profit, the government contributing £4,023 per mile for 604 miles at the outside.

This portion is leased to the North Western Railway Company for a term of sixty years, with a special stipulation stating that the rolling stock, of a value of at least £187,500, must be so built as to be easily and speedily convertible into troop trains.

The company is, moreover, allowed to build temporary bridges or to run ferryboats across the Parana and Paraguay rivers, as the whole line must be finished in a very short space of time. The ferryboat solution has been adopted.

Gradients and curves were to be particularly easy, so as to allow easier handling of military plant, and the required speed was 38 miles an hour. The gradients have been limited to 1 in 100 and the curves to 990 feet radius, except at the separation of the watersheds, where gradients of 1 in 83 are allowed and curves of 495 feet radius.

The company was obliged, by contract, to start work both in Itapura and in Esperança within a month and to open the line, in a temporary con-

dition at least, not later than September 30, 1910, as far as the Paraguay river. The whole line to the frontier must be finished fifteen months afterwards under penalty of forfeiture of the 15 per cent. of government reimbursements, which have been withheld.

The lease is based on the gross receipts, 5 per cent. of which the company pays to the government as rental should the return be less than £305 per mile. There is a 5 per cent. increase per £31 up to 25 per cent. on all earnings above £508.

Besides this variable rental there is a fixed tax of 20 per cent. on the net earnings above £625.

The now usual stipulation regarding the development of colonies along the line have been inserted. This is hardly an inconvenience, as such colonies are bound to be useful.

The building has been speedy, and would have been more so had it not been for the malarial fevers. The line was opened to—

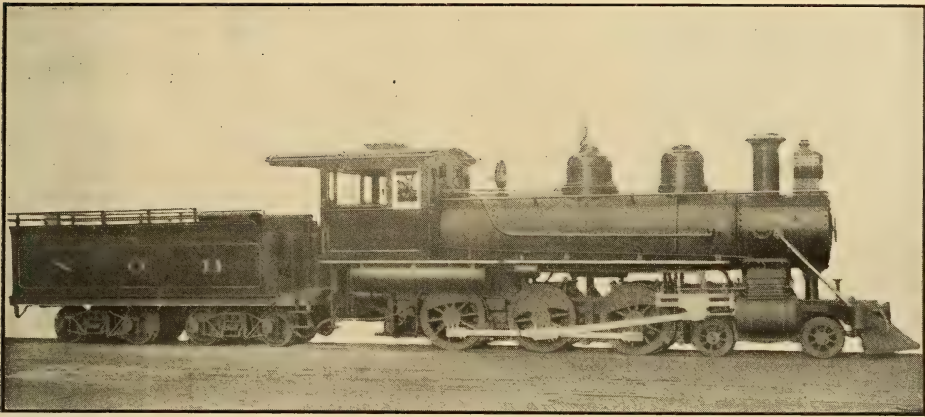
STATION AND DATE.	Miles.
Jacutinga, Sept. 27, 1906.....	30
Lauro Muller, Jan. 1, 1907.....	57
Miguel Calmon, Feb. 16, 1908.....	127
Glicerio, Sept. 1, 1908.....	150
Aracatuba, Dec. 2, 1908.....	176
Corrego Azul, Dec. 31, 1908.....	188
Anhargahy, May, 1909.....	213
Itapura, October, 1909.....	271

The remainder will be built still quicker and the 500 miles probably completed in accordance with the contract.

The first section that is open to traffic runs down the Tiété valley, crosses the river where the latter runs through a gorge called "Hell's Canal," and follows the right bank to Itapura, on the Parana river, where the latter separates the States of Sao Paulo and Matto Grosso.

The Urubu-Punga Falls, opposite, separate the navigable reaches of the river—the upper one, 60 miles long to the confluence of the Paranahyba and Rio Grande rivers, and the lower one, 315 miles, down to the Sete Quedas Falls. A number of the tributaries of the river are navigable as well, thus adding a large mileage

The large tract of land lying between the Parana and Paraguay rivers comprises two distinct regions. In the east is a high tableland stretching to the watershed limit, where it drops abruptly; it is well watered, and covered with small woods and pastures. The western portion is formed of low-lying land, flooded periodically. It is made up of a series of "pantanal"—not regular marshes, but land having too slight a slope for the rain to run off. Thus the Paraguay is 720 feet above sea level in Cuyaba and 345 feet in Corumba. As the distance between these towns is 312 miles as the crow



4-6-0 LOCOMOTIVE FOR NORTH WESTERN RAILWAY. BALDWIN LOCOMOTIVE WORKS

to the means of communication of the region.

The Urubu-Punga Falls are 33 feet high, and represent energy of some 500,000 horse-power, to which the Tiété Falls, 36 feet high, at its mouth, add another 60,000 horse-power.

An island, opposite Itapura, helps the railway across. The bridge will have a first span of 312 feet across the lesser channel, then four 312-foot spans and one 417-foot at the Jupia bank. The total length will be 1,977 feet. The metal portion weighs 2,397,298 tons. The piers will be built so as to withstand a 10-foot-per-second current. The cost is estimated at £168,074.

flies and 521 miles along the river, the declivity in the first case is 1 in 4,400, and in the second 1 in 7,300. It is even slighter beyond, to Patria, 1,138 miles downstream, being only 1 in 44,000. The tributaries are no better. The Aquidauana, for instance, between the town of Aquidauana and the mouth of the river, has a declivity of but 1 in 7,600, or 1 in 3,500 as the crow flies.

No wonder the country is frequently under water and the railway obliged to keep 13 feet above it!

The tributaries of the Paraguay do not take their source along the ridge I have spoken of, but far beyond, on the tableland, and run westward, breaking through the rim in deep

ravines. This rim is formed by the western slope of the Serras of Maracaju, Sao Jeronymo, etc.

The plateau contains some 130,000 square miles of excellent land suitable for grazing and some 15,000 square miles of land proper for colonization.

The State has constituted a reserve of "national land" along the whole of the railway line and 62½ miles wide on either side.

From the Vacaria river southwards, and as far as the frontiers of Republic of Paraguay, lie plain upon plain of maté bushes, extending over 14,000 square miles, leased to the Motto-Laranjeiras Company, that exports annually some 7,000 tons of maté tea.

I have described this region somewhat in detail because it in no way resembles the geography of the country such as we have learnt it. Instead of running across a kind of desert, the railway runs through excellent land, and will have no less than ninety important bridges between Itapura and Esperança, aggregating 9,675 feet and requiring 4,270 tons of steel. The cost per mile is estimated at £8,193.

The line will cross the Paraguay river on a long bridge with a swinging section, to allow the boats to pass. There will be three spans of 270 feet, then the swing bridge, followed by two 100-foot spans and a couple

or so more to guard against floods.

The company had hoped to be allowed to put off the building of the short section on to Corumba, which is a most costly one; but this has not been allowed. It will necessitate 23½ million cubic feet of embankment, and is expected to cost £13,000 per mile.

This extension has been imposed because the line is likely to be extended through Bolivia, thus forming a through line of communication between the Atlantic and Pacific Oceans, 2,472 miles long.

It would reach Santa Cruz de la Serra, crossing the Guaporé and Chimoré, where they become navigable and can serve as feeders to the railway, and so on to Orura, where the Antofogasta Railway leads down to the coast.

This latter line passes at Huduhaca, where it will meet the new Chilian longitudinal railway, which has just been determined. Work on the La Paz-Arica portion of this road has been started.

The Argentine Republic is also competing for this part of Bolivia's traffic, but with little chance of success. The northern portion is bound to use the Madeira & Mamoré Railway. As for the rest, the distance from Santa Cruz to Santos will be 1,640 miles, and 2,198 from La Paz.

On the other hand, the length of



ENGINE FOR NORTH WESTERN RAILWAY. 2-4-0 BALDWIN LOCOMOTIVE WORKS

the Argentine line to La Luiaca is as follows:

	Miles.
Buenos Ayres and Rosario.....	190
Rosario and Tucuman	538
Tucuman and Perico	294
Perico Ledenna	51
Ledenna Oran	57
Oran Yacuyba	122
Yacuyba Santa Cruz (in Bolivia).....	440

1,684

This line is a little longer than the North Western route, which is about 1,000 miles shorter to Europe.

Nor is the line useful and shorter to Bolivia only. Esperança will be brought within 548 miles of Itapura, 822 of Bauru, and 1,145 of Santos. Corumba is 92 miles further.

Now, when traveling from Rio de Janeiro to Corumba, travelers are obliged to proceed around Montevideo and up by river steamers through the two foreign Republics, 2,778 miles of navigation, 1,671 of which in river steamers. There are still 459 miles of river navigation before Corumba is reached and 521 miles further to Cuyaba.

The journey will be reduced from more than one month, which it now always takes, to about three days.

The saving in money is just as great. As an example, let us take the freight of a ton of merchandise to Campo Grande, 250 miles from Esperança. This will show at the same time the rates now prevailing in this part of the world.

A ton of goods from Buenos Ayres to Campo Grande now pays:

	£	s.	d.
Buenos Ayres to Corumba, per river steamer	3	2	6
Corumba-Aquidauana, per river steamer.....	6	5	0
Aquidauana-Campo Grande, by cart....	6	5	0
	15	17	6

Taking the new railway's freight charge at 150 reis per ton-kilometer (3.615*d.* per ton-mile) for short distances and two-thirds of this for long distances, the corresponding freight from Buenos Ayres to Campo Grande would be:

	£	s.	d.
Buenos Ayres Esperança by river, owing to competition	2	10	0
Esperança Campo Grande, 250 miles, short-distance freight	3	14	7
	6	4	7

From Santos the comparison would lead to a similar conclusion:

	£	s.	d.
Santos Uberaba, by rail, 442 miles.....	4	18	10
Uberaba Campo Grande, 625 miles, per pack bull	31	14	0
	36	12	10

Whereas, by the new railway, this will be reduced to 9 pounds.

The future of the railway seems thus tolerably good. The cost of the line is estimated at £5,075,160, or £8,460 per mile, rolling stock included.

The rolling stock is increasing continually; it comprises now 20 locomotives and 200 wagons.

THE TESTING OF FUELS

THE WORK OF THE UNITED STATES BUREAU OF MINES

By Herbert M. Wilson, C. E.

The following account of the important work which is being done in connection with the study of the commercial value of various fuels by the United States has been prepared by the engineer-in-charge of the laboratory at Pittsburg, Pa., and is published by the express permission of Dr. Joseph A. Holmes, director of the United States Bureau of Mines.—THE EDITOR.

COAL or fuel testing, as distinguished from the testing of boilers, gas producers or other power-producing devices, is a comparatively modern development. Yet an appreciation of the need of coal testing is almost as ancient as the use of coal for fuel. One of the earliest printed references to coal testing is in a quaint pamphlet by H. Plat, Esq., on "Coal-Balles," or briquets of coal, which was "Imprinted at London by Peter Short, dwelling at the signe of the Starre, on Bredstreet hill, in the year 1603." H. Plat states: "First, I do hold it an infalliable rule to know a good cole by—viz., if the same being held ouer a candle, or rather ouer a flaming fire, do melt & as it were drop or frie: for this is an argument of his fattie and sulphurous nature, which ministereth store of foods for the fire; but if the same grow hard & drie ouer the flame, it is a signe of a leane and hungrie cole, and such as will not cake or knit in the burning: of which kind are the Sunderland coles." To quote further: "Secondly, the brightnesse and glittering of the coke, both within and without, is some argument of his goodness." A proof which H. Plat speaks of as most assured of all the rest is, "So especially in water, doth argue either his pureness or impureness: for the lighter and clearer water, euer held the better and more wholsom, as least participating with earth or minerals." In this test the author strikes at the real essence of the differences in coal and that which,

as will be shown later on, is the primary guide in the modern methods of determining the relative heat-producing values of coals. The author falls down and returns to what we now consider the older and cruder method of distinguishing coals when he holds as the "plainest and most iuidient triall of all other, first to cause a conuient fire to be made of some parcell of the coles of euerie ship, before the owner is suffered to vnload, with a special charge giuen, that if the whole bulke do not fall out to be of the selfe same and equall goodnesse with the sample, that the rest should either be returned or confiscated, if any law or customs of that place will beare it."

This last method of testing coal nearly approaches that commonly adopted under the old and still prevalent plan of purchasing coal. Under this plan when the owner thinks he has cause to find fault with the quality of fuel he has received he is, in many cases, assured that it must be good, because, like all the other coal sent him, it comes from a mine with an established reputation. Such a state of affairs makes it difficult to take advantage of the competition which usually results when a considerable number of bidders are asked to submit prices. The purchaser is afraid to buy from any but such dealers as he knows and trusts, because, although each dealer claims that his coal is equal in quality to that of others, yet if it prove unsatisfactory, there is no standard for settlement or for cancellation of the

contract. Many thousands of dollars' worth of coal are bought each year in this manner, but the purchasers would consider it ridiculous if they were asked to contract for a building with no specifications and simply on the agreement that it should be of a certain size and well constructed. Neither would they buy gold, silver, or even copper and iron ores on the mere information that they were mined at certain localities. All products of mines are now purchased to a great extent on the basis of their value as shown by chemical analysis. This is true of coal in only a small degree, but the number of contracts made on this basis is increasing every year.

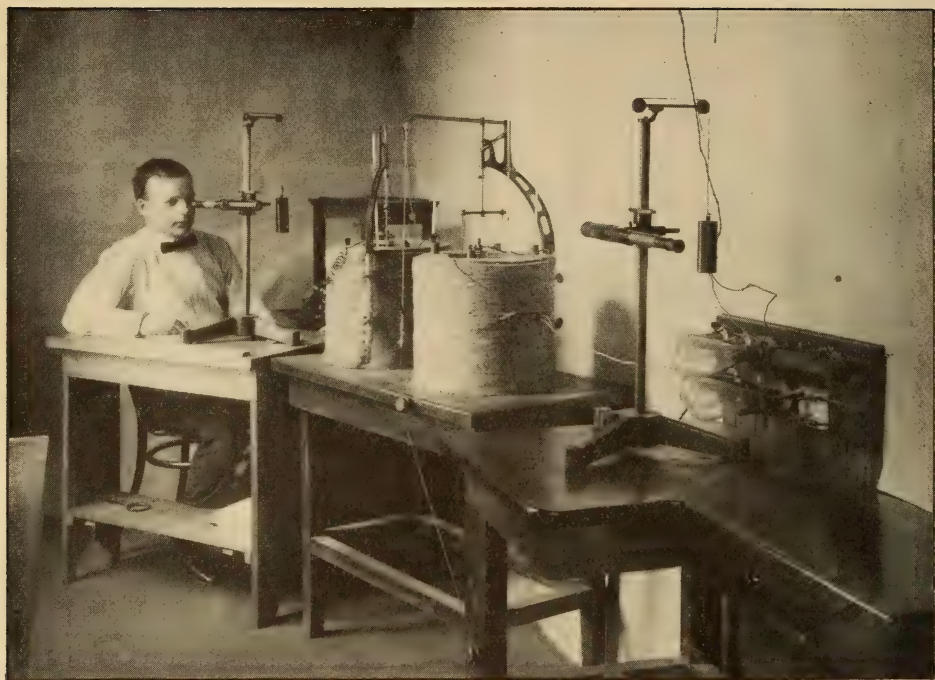
The newer, or modern method of purchasing coal on a specification fixing the number of heat units, the contents, and, in some cases, the maximum amount of ash, or of moisture it may contain, furnishes the basis for all modern requirements in fuel testing, and is fully set forth in Bulletin No. 11 of the United States Bureau of Mines under the title "The Purchase of Coal by the Government Under Specification," by George S. Pope. This method of coal purchases is as advantageous as is intelligent understanding regarding the quality or other feature of any other product, or a building specification, or engineering project. He who buys coal under a specification fixing the number of British thermal units as the basis thereof gets what he pays for and pays for what he gets.

As an essential preliminary to the establishing of any equitable heat-unit specification as a basis for coal purchases a knowledge must be had of the heat values and chemical composition of the coals available. The chemical analyses and the B. T. U. values do not, however, furnish all the data on which to establish the relative merits of any one coal as compared with any other. Coal which may be high in heat units and low in ash may, because of chemical

composition of ash, give low efficiencies with certain furnace installations, because of the fusing, clinkering, or other unfavourable behaviour of the ash, or, because of unfavourable physical characteristics, it may not burn as freely with one type of grate or arrangement of combustion chamber and draft as with another. It is, therefore, necessary, in order that full knowledge may be had of all those properties of the various coals which may indicate one as a more efficient heat and power producer than another when burned in any particular type of furnace installation, that the chemical analysis be supplemented by complete combustion tests.

Until within the last decade little thought had been given this phase of coal testing. Boiler tests, producer gas and gas engine tests have been made by the thousands; but these have nearly all been conducted with the primary view to determining the relative performance of the machine. Their purpose was, and still is, to ascertain whether a combustion device furnished on certain specifications complied in performance with those specifications. Rarely was the coal used in such test considered, other than by general trade distinctions, as anthracite, perhaps of one size or another, or bituminous, perhaps, in the broader sense, from one coal field or another.

The first definite step toward scientific coal testing taken in the United States, aside from the few scattered fuel tests made by a few of the larger and more intelligent coal consumers and at a few of the universities, was the provision by Congress in 1904 for an exhibition at the Louisiana Purchase Exposition, St. Louis, Mo., of fuel testing. This has been followed up by annual appropriations for fuel testing under the Department of the Interior, which work is being conducted as one of the principal energies of the Bureau of Mines. In the course of these studies proximate chemical

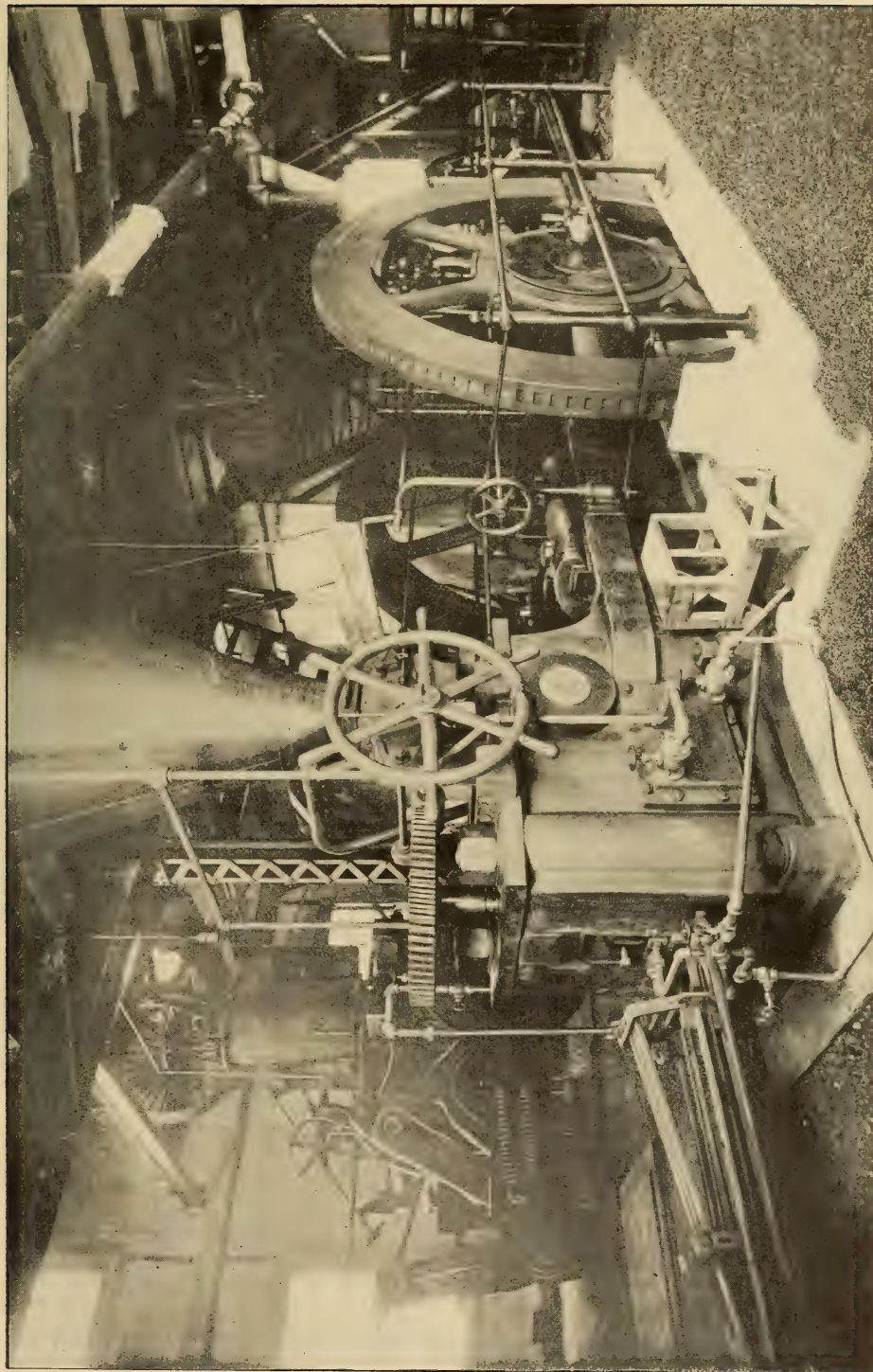


A FUEL TEST IN THE COAL CALORIMETER

analyses with calorimetric determinations of heat value and supplemented, in many cases, by ultimate chemical analyses, have been made of more than five thousand separate mine samples of coal, the origin and history of which are authenticated. These samples have been collected by the mining engineers of the bureau and by geologists of the Geological Survey, and samples have been tested of the coal as mined, as loaded on the cars, as unloaded at the testing station, and as fired. A bulletin is in course of preparation setting forth the coal field, coal seam or bed, location within the mine, analytical data, and other pertinent facts concerning these samples, and, when published, may be had on application to the Director of the Bureau of Mines. With this information, it will be possible for the government purchasers and users of coal, and for commercial consumers, to predict the character of the coal which may be furnished them from any mine in the United States. Through the

medium of the ultimate analyses it is possible to determine whether coal specified by the name of a coal field or colliery, as, for example, Pocahontas No. 3, actually comes from that seam or some other seam carrying a less high-grade coal, though drawn from the same shaft and through the same tippie.

For the most intelligent use of these data as a basis upon which to distinguish the relative fuel values of the various coals, these chemical data must be studied in the light of authentic steaming, gas producer, briquetting and coking tests. The Geological Survey and its successor, the Bureau of Mines, have conducted and have published, or have in course of publication, the results of steaming tests made under boilers of standard type and capacity upon over 600 separate coals mined in every portion of the United States from Virginia to Washington, and including coals from the Philippine Islands, Alaska and the Argentine Republic. In like manner producer gas tests have been



BRIQUETTING MACHINE USED FOR TESTING FUELS IN THE UNITED STATES BUREAU OF MINES

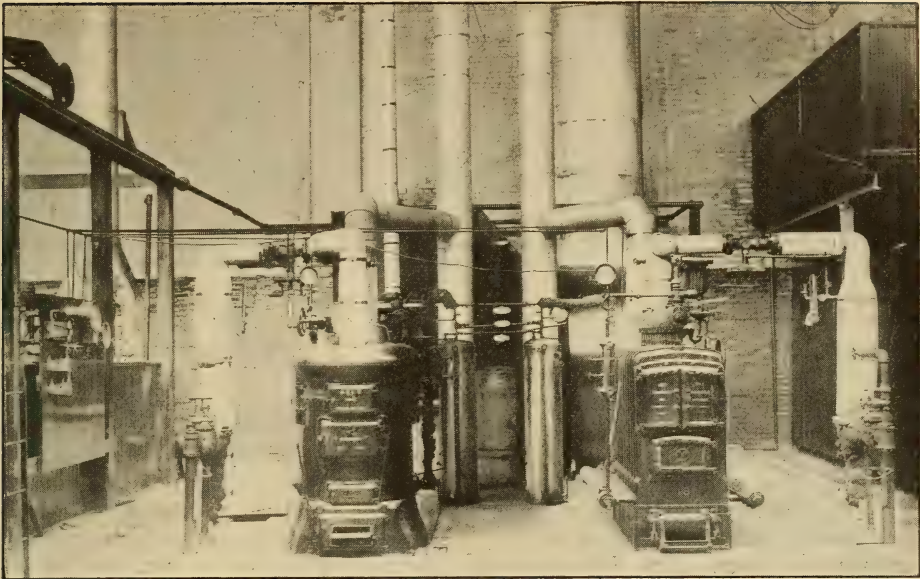
made on carload quantities of over 200 of the representative coals, lignites and peats of the United States. About an equal number of briquetting tests have been made of all of these fuels to determine the methods of briquetting, pressures necessary, binder, if any, weathering and combustion qualities of these coals when compressed into briquets. About one hundred and sixty washery and coking tests have been made on the various American coals, preliminary examination of which has indicated the possibility of their furnishing coke of a metallurgical quality. About twenty tests have been made under similar conditions to determine the relative value of such coals for producing illuminating gas.

In considering the value of all these fuel tests it must be borne in mind that they have been conducted by the highest impartial authority in America—the Government of the United States. They have been made primarily to furnish accurate information for the guidance of the several hundred purchasing officers of the various government bureaus and public buildings, in order that they may be enabled to provide that fuel which will give the most efficient results upon the installation available. These results are then made public in bulletins of the Bureau of Mines. It is evident that results of such tests can have no bias and reflect no influence of commercial interests, to which doubts tests made by coal producers, or coal consumers, or, in some cases, university representatives, may be subjected, divorced, also, as are the government tests from the influences of variations in types of apparatus and of personnel.

All of the several hundred steaming tests have been made on one standard selected type of water-tube boiler of 210 rated horse-power capacity. A large number of such tests have been made on a single standard design of horizontal return fire tubular boiler of 50 rated horse-power capacity. Several hundred tests

have been made on three sizes and types of house-heating boilers. These latter tests have had in view, primarily, the furnishing of information to the Quartermaster's Department of the Army relative to the most efficient coals locally available to the various military posts throughout the United States, and for use in heating buildings of large size, as a barracks, or of intermediate size, as a hospital or assembly hall, and of residence size, as officers' quarters. Whereas these results are now available to the War Department, they have not as yet been published, but this information is now in course of publication. One series of such tests has been published as Bulletin 366 of the Geological Survey, entitled "Tests of Coal and Briquets as Fuel for House-heating Boilers," by D. T. Randall. The results of the tests on the horizontal return tubular boiler have not gone far enough to warrant publication. These tests are now being conducted, primarily, with a view to showing how the more volatile coals may be burned with less smoke, and, therefore, with the highest efficiency, and when complete the results will be published. Several publications have been issued setting forth the results of the steaming tests made on the water-tube boilers, or special features developed in the course of these tests. A bulletin which all coal consumers should possess is No. 325, "A Study of Four Hundred Steaming Tests," by L. P. Breckenridge. Among the bulletins setting forth supplemental results are No. 373, "The Smokeless Combustion of Coal in Boiler Plants," by D. T. Randall and H. W. Weeks; No. 367, "Significance of Drafts in Steam-Boiler Practice," by W. T. Ray and Henry Kreisinger; No. 8, "The Flow of Heat, or Heat Transmission," by W. T. Ray and Henry Kreisinger. And in course of publication is a complete résumé of all steaming tests made in the Geological Survey and Bureau of Mines during the years 1904 to 1909.

These steaming tests have been



HOUSE HEATING BOILERS ARRANGED FOR TESTING

made in accordance with the revised standard code for conducting boiler tests as established by the American Society of Mechanical Engineers. They have covered such a wide range of fuels that they may be characterized as a combustion survey of the coals of the United States. These coals are burned in furnaces in which the baffling is changed from time to time. They are hand-fired or mechanically stoked with under-feed, over-feed, or chain-grate stokers. The drafts may be so regulated as to be natural, forced, induced, or a combination of the latter. It has thus been possible to determine, in a preliminary way, what type of furnace, how baffled, how fired, how stoked, and with what draft each type of coal should be burned in order that it may produce the highest efficiency and emit the least smoke. In the course of these tests feed-water is weighed and analyzed, ash and clinker are weighed and analyzed, and gas analyses and temperature measurements are made in the furnaces and in the flues. These data furnish an invaluable indication to the best methods of utiliz-

ing each coal, and, by co-ordinating them with the chemical analyses of mine samples, pave the way for future investigations along these lines.

In so brief a paper as this it is impossible to set forth in detail either the methods of making chemical analyses or those of making furnace or gas-producer tests. These methods are essentially those with which all mechanical and testing engineers are familiar. The results of these government tests are more valuable as coal tests than those published elsewhere, because of the authenticity of the origin of the coals and the standardization of the appliances upon which these various coals have been tested, thus rendering the results comparable. Those who desire to inquire further concerning the methods of analysis or testing are referred to standard works on these subjects, or to the bulletins of the Geological Survey and the Bureau of Mines. In addition to such bulletins as have already been enumerated, is one known as Professional Paper No. 48, "Report on the Operations of the Coal-Testing Plant of the United States Geological Survey," by E. W.

Parker, J. A. Holmes and M. R. Campbell. Also, Bulletin No. 323, "Experimental Work Conducted in the Chemical Laboratory of the United States Fuel-Testing Plant," by N. W. Lord. A bulletin, No. 22, of the University of Illinois, "Fuel Tests with Illinois Coals," by L. P. Breckenridge, S. W. Parr and H. B. Dirks, also deals with methods of testing in detail, as do bulletins, mentioned hereafter, consider methods of testing in other than boiler furnaces.

With fixed appropriations and the permanency of the work better assured, the Bureau of Mines has, since its organization in July last, procured the equipment and commenced investigations of a more fundamental nature based upon these preliminary tests. An exaggerated furnace, named a long combustion chamber, has been perfected and put in operation. This is nearly 45 feet in length from the fire door to the boiler tube and approximately 3 feet in rectangular inside cross-section. The inner lining is of firebrick. At every 5 feet of its length are peep-holes and work-holes, where the appearance of the flames may be observed, and temperature measured and gas samples taken from any part of the cross-section. In all, thirty-six simultaneous gas samples may be taken in different parts of the furnace.

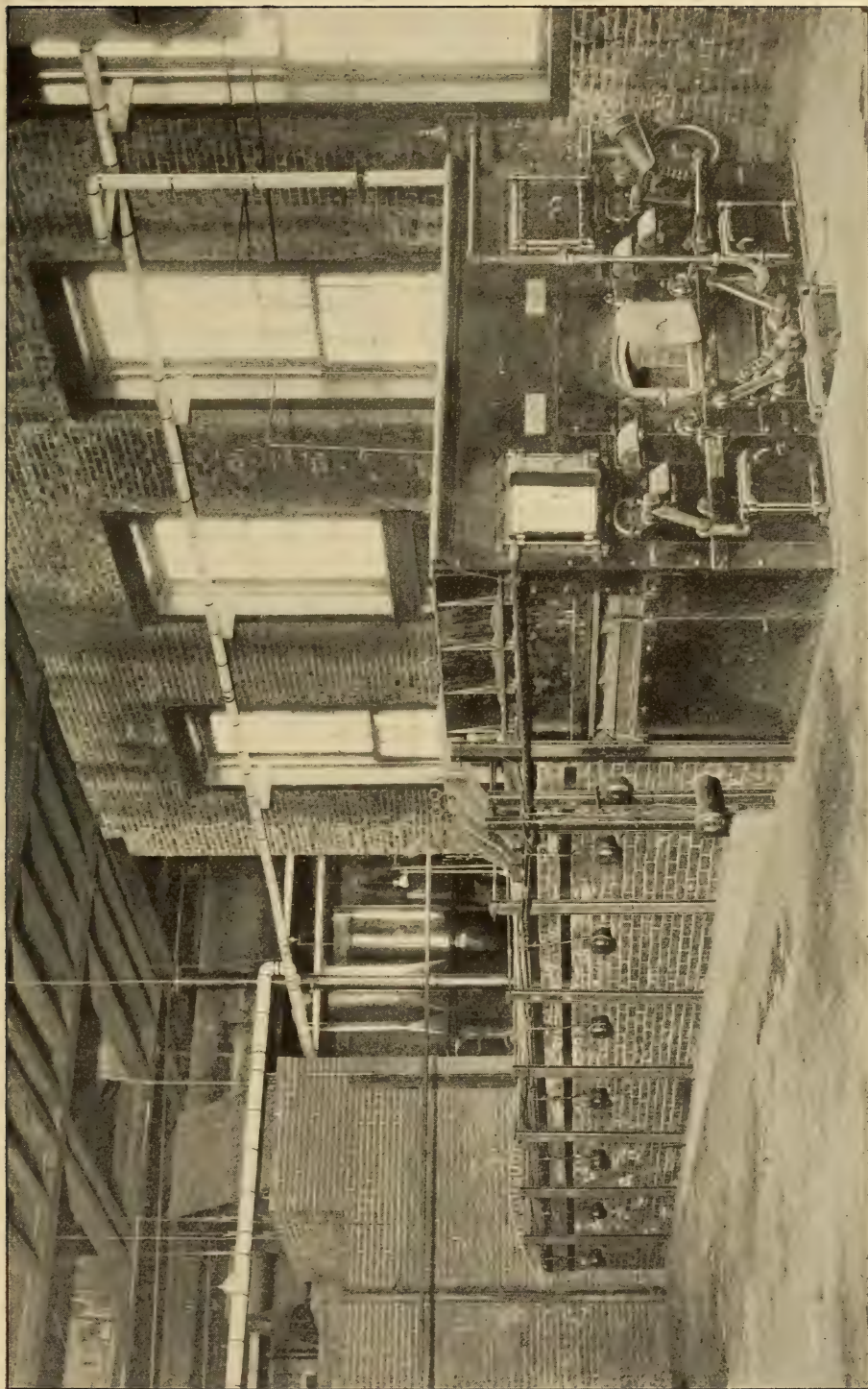
In this appliance coals are burned under fixed conditions of firing and draft, and it is believed that many of the fundamentals of fuel combustion will here be better developed. It should be possible to determine just what length of furnace is necessary to procure the most efficient mixture and highest temperature in the fuel gases from any coal and that necessary for the emission of the least smoke. These first investigations will be followed by others, in which different arrangements of baffling or different cross-sections will be given the combustion chamber.

As previously stated, another line of coal testing, to which much atten-

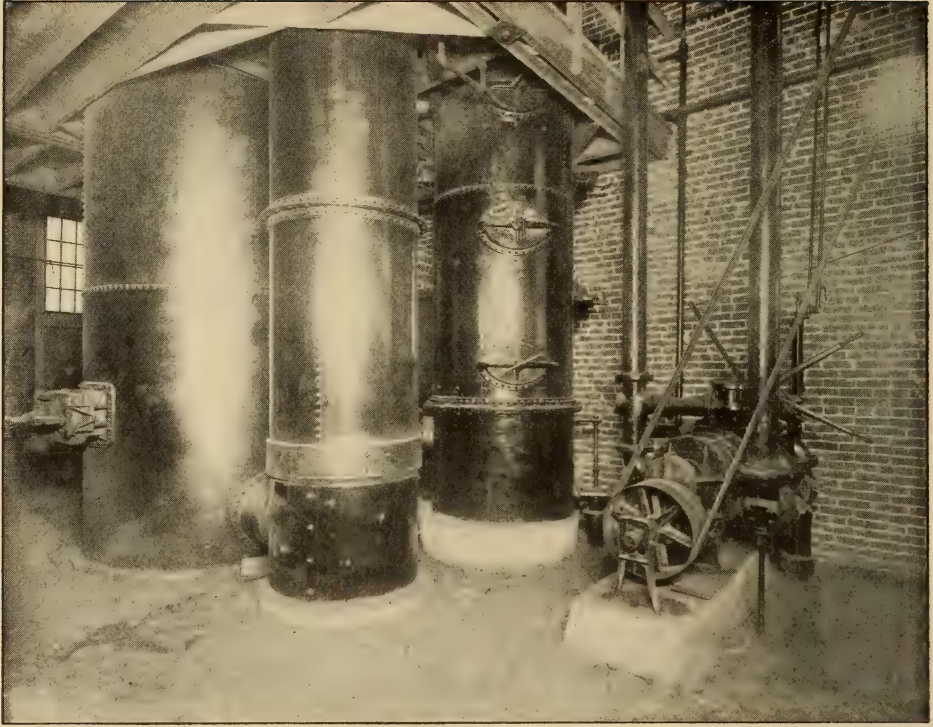
tion has been given in recent years by the Geological Survey and the Bureau of Mines, concerns the value of such coals when used to generate producer gas or for the making of briquets, for coking or for illuminating gas. All these tests and investigations have been accompanied by the same care in fuel sampling and in chemical and physical analyses and measurements as has been taken with the steaming tests. The producer-gas tests have been made on two standard types of gas producers—one a down-draft, the other an up-draft producer, each of about 150 rated horse-power capacity. As a result of these tests the bureau has designed an experimental producer of 150 horse-power capacity, which may be operated either as a pressure or as a suction producer. It is so arranged that gas samples and temperatures can be taken at various points in the fuel bed, the formation of clinker be studied, and the problems concerning the efficiency of the firebrick lining, and the several processes which take place within the producer can be thoroughly investigated. The preliminary tests in this apparatus will have to do with the effect of depth of fuel bed, different ratios of air to steam, and with different rates of combustion with various types of fuels.

In the producer gas tests previously run no difficulty was experienced in making runs of a week's duration on a fuel, including the most volatile bituminous coal, lignite and peat. Comparisons of the several hundred tests run on coals from different parts of the country in the steam boiler and gas producer are most interesting. The gas producer operated in the best way with West Virginia coal produced an efficiency 3.3 times as great as did the steam boiler of the best type operated on the same fuel in the best way in test practice. The lowest grade of lignite developed in the gas producer about the same efficiency as did the best steaming coal under the boiler.

The many briquetting tests made



LONG COMBUSTION CHAMBER FOR INVESTIGATING THE BEHAVIOUR OF FUELS



GAS PRODUCERS ARRANGED FOR TESTING FUELS

and published by the Bureau of Mines and its predecessor were, like the steaming and gas-producer tests, conducted on a large commercial scale upon many different coals and lignites, briquetted in carload lots. In the first series of these tests the runs were on a quantity of only ten or twenty tons of the several representative coals from all parts of the United States. In some of the later tests 100 tons to 200 tons of one type of coal has been briquetted, with a view to determining the relative commercial cost and value of briquetted coal both in the manufacture and in combustion tests as compared with run-of-mine coal. The weaknesses of the mechanical methods, both in the briquetting plant and the binder, having been developed by these tests, investigative work is being conducted on a small hand briquetting press, supplemented occasionally by larger or commercial tests. These experimental tests are planned with a view

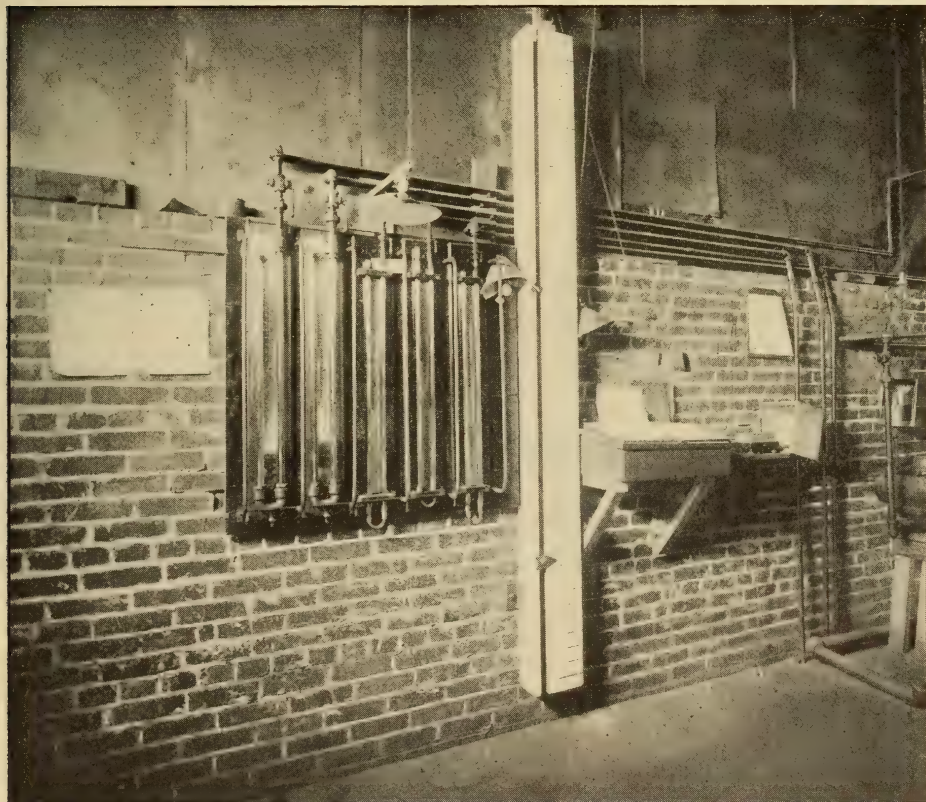
to determining the proper pressure and method of application of same, character and amount of heat necessary, kind and amount of binder, etc. Latterly tests have been made on several carloads each of lignite from Texas, North Dakota and California to determine the best method of briquetting these without binder, and the relative value of the raw and briquetted lignite in combustion in different types of furnaces. In briquetting coal it is ground and mixed with a small percentage of binder, usually 5 or 6 per cent. of pitch. It is then heated and briquetted under a pressure of one or two thousand pounds per square inch. These coal briquets burn from the outside, giving off the volatile matter slowly and coking as the combustion proceeds until the entire briquet is consumed. In their physical behaviour they burn much as does furnace anthracite.

Of particular interest to consumers of coal in locomotives and marine

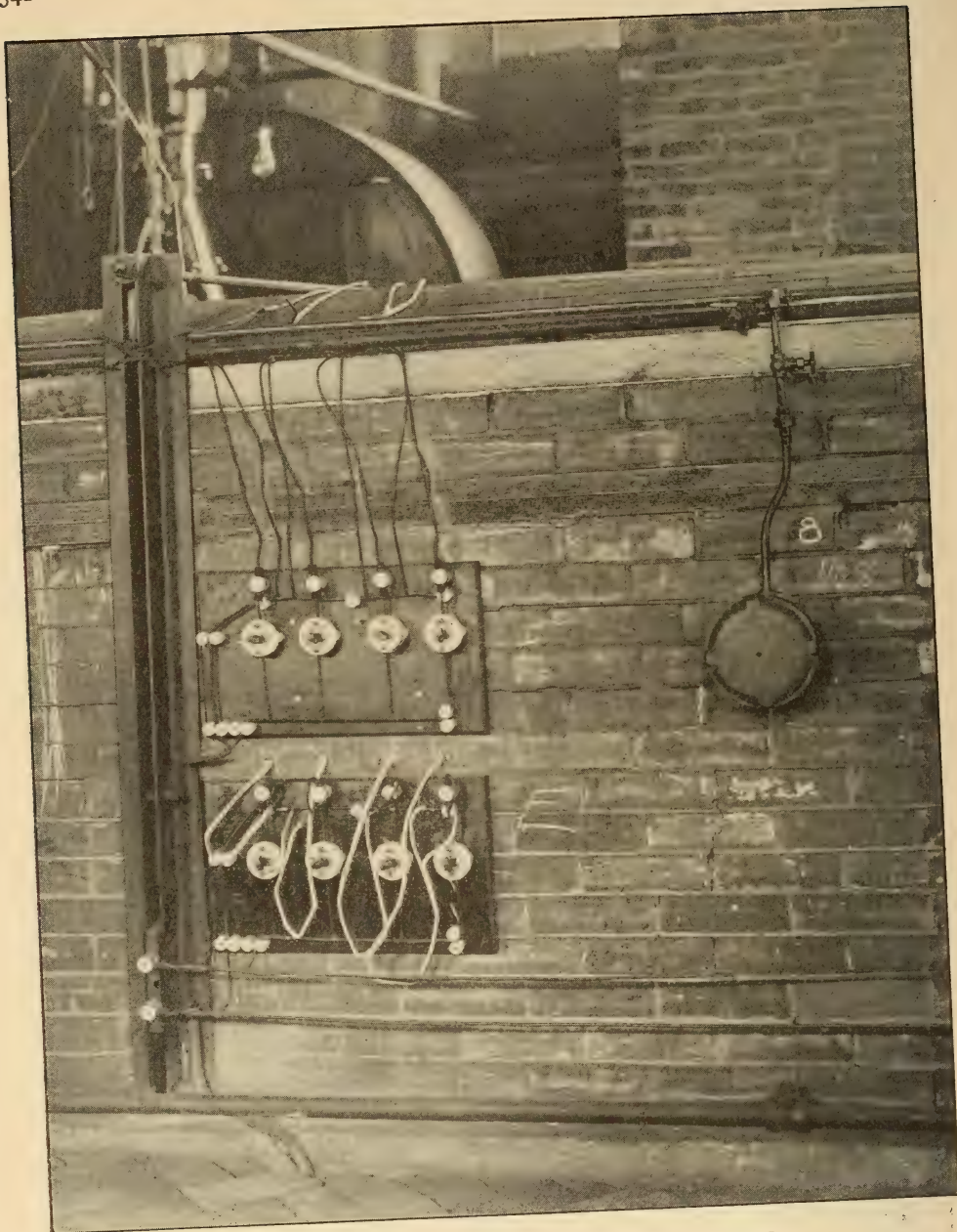
boilers is Bulletin No. 363, "Comparative Tests of Run-of-Mine Coal on Locomotives, Including Torpedo Boats," by W. F. M. Goss, and Bulletin No. 403, "Comparative Test of Run-of-Mine and Briquetted Coal on the Torpedo Boat *Biddle*," by W. T. Ray and Henry Kreisinger. Also, Bulletin No. 402, "The Utilization of Fuel in Locomotive Practice," by W. F. M. Goss, and Bulletin No. 412, "Tests of Run-of-Mine and Briquetted Coal in a Locomotive Boiler," by W. T. Ray and Henry Kresinger. Among the more important bulletins setting forth the results of producer-gas tests and method of conducting same are Professional Paper 48, above referred to, and Bulletin No. 332, "Report of the United States Fuel-Testing Plant at St. Louis," by J. A. Holmes, in charge; also, Bulletin 416, "Recent Development

of the Producer-Gas Power Plant in the United States," by R. H. Fernald; Bulletin No. 393, "Incidental Problems in Gas-Producer Tests," by R. H. Fernald, C. D. Smith, J. K. Clement and H. A. Grine; and also two bulletins about to be published by the Bureau of Mines, No. 7, "Formation of Producer-Gas," by J. K. Clement and others, and No. 13, by R. H. Fernald and C. D. Smith, "Gas-Producer Tests."

It is very interesting to note, as set forth by H. Plat, that the art of briquetting, like that of coal-testing, dates back at least to the year 1600. At first he refers, incidentally, to "the great difference between their former fires of seacole, and this newe and sweete composition," which he, a little later, refers to as "cole-balles." Quaint indeed, but quite modern and up-to-date, as a champion of the peo-



ARRANGEMENT OF DRAUGHT GAUGES ON GAS PRODUCERS



SWITCHES FOR THERMO COUPLES ON LONG COMBUSTION CHAMBER

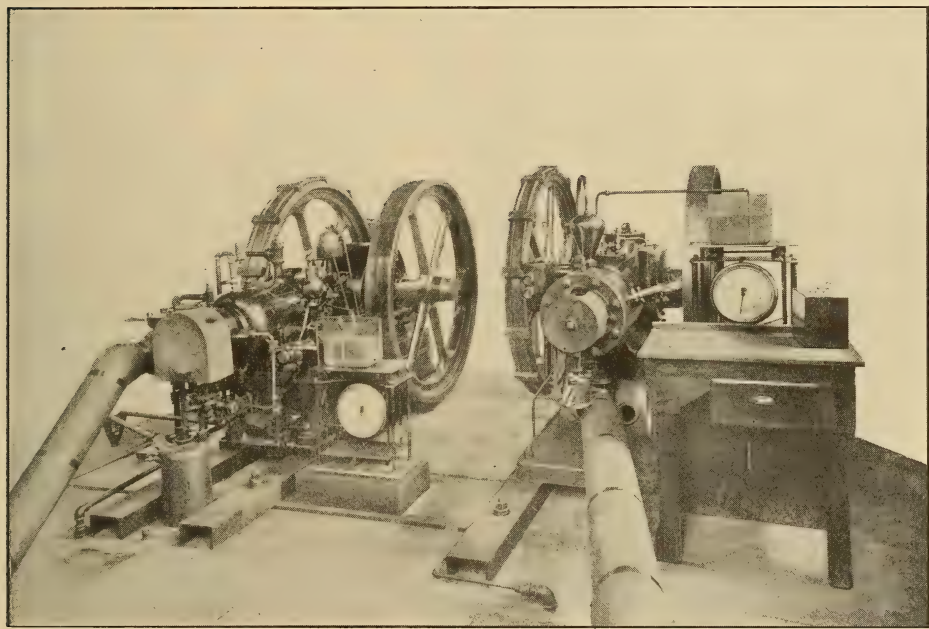
ple against the interests is H. Plat's comment: "I could not (on the sodaine) bethinke myselfe of a better discoverie, than how to imploy the poore and maimed persons of this land, who (hauing their hands only) might be sufficiently able to

work vp these sweet and profitable fire balles, for the benefit and pleasure of the rich. So if now in the scarsitie of fewel I may also proue so happy, as to bringe forth a cheap and sauing fire to warme and cherish their cold and frozen limnes, with

the recompense of their labours, I shall be greatly encouraged." Even more interesting is his suggestion that the excellent spirits of the land "by some act of Parliament priueleged to themselves for some reasonable time, with some proportionable part of the gaines reserued for the succour of the poore (a matter well mowed of late, but crossed and swallowed vp, I know not how in the bare and naked word of Monopolies)."

H. Plat then goes on to describe in detail how, in the winter season, after some few frosts have broken

"cole-balles" and dried, "according to the manner of Lukeland in Germanie." Here the art of briquetting coal is taken back presumably beyond 1600 into Germany. Still more modern is the suggestion that, as a binder, instead of loam, sawdust may be used as "The second and sweetest fire of al the rest, but not so lasting as the first"; also does he suggest another of our modern binders—ashes; still another—peat. He then gives instructions regarding methods of combustion of "cole-balles," and, not to be behind we moderns in any-



OIL ENGINES ARRANGED FOR TESTING

up the loam, we should gather up a certain amount of this and dissolve it in a tub of water, knitting it up well with a bushel of "seacole into fire-balles"; how the loam and "seacoles" will be incorporated into a very thin pap. He describes in detail that the "seacole," if of large size, should be strewn on a stone floor and hammered to a powder with a mallet; how the thin pap should be poured over the heap and then moulded with the hands into

thing concerning coal combustion, he refers to the smoke nuisance thus: "And therefore my opinion is, that the smoke which in our vsuall fiers dooth immediately ascend from the seacoles vnprepared, must needs, according to the soule and grosse matters of the cole, be also foule and smooty it selfe. But when the smoake doth passe and searsed through the lome (which is the band that knitteth the coles together) it is then so refined and subtilated before his pene-

tration as that it either consumeth or swalloweth vp." Here is repeated the argument of the present-day advocates of briquets, who, among other things, claim for them that they burn with less smoke than does the run-of-mine coal.

Returning now to the briquetting tests of the Bureau of Mines. In the conduct of those made on lignite this material is first disintegrated, then dried to free it of excessive moisture, and is then briquetted under much greater pressure than that used in briquetting coal—namely, about 20,000 pounds per square inch. The result is briquets as firm and hard as anthracite, and, being made without pitch or other binder, are burned with comparatively little smoke. Lignite briquets are especially well adapted for combustion in locomotives and in house-heating furnaces and ranges. The fuel, like slack coal, may be had at the mines at about \$1 per ton; adding \$1.50 for manufacture, a product is obtained at \$2.50 per ton at the mine which compares favourably with high-grade bituminous or anthracite coal.

Since the government and the railways own some millions of acres of lignite in the Western States, this will undoubtedly be an economical

source of coal supply when its manufacture on a commercial scale is perfected. Many of my readers will recall the conditions under which, a few years ago, a coal famine occurred in mid-winter in North Dakota. This was due, in a large measure, to the reliance of that region on the slack coals of neighbouring States, which could not be carried long in storage and called for daily deliveries. Heavy snow-drifts impeded transportation, and the resulting suffering ensued. Briquetted lignite from local sources can be carried in storage throughout the winter months. For those seeking further details concerning briquetting tests of coal, Professional Paper No. 48, above referred to, should be consulted; also, Bulletins 332, 363, 366, 403 and 412, above quoted. In addition, and of more especial interest, are Bulletin No. 343, "Binders for Coal Briquets," by J. E. Mills; Bulletin No. 385, "Briquetting Test at the United States Fuel-Testing Plant," by C. L. Wright, and a forthcoming Bulletin, No. 14, of the Bureau of Mines, "Briquetting Lignite," by C. L. Wright.

All of the above-quoted bulletins can be had from the Director of the Bureau of Mines in Washington.

MACHINE TOOL NOTES

By Fred Coxon

EVOLUTION OF STANDARD DESIGNS

THE law of the survival of the fittest as surely governs machinery as it does natural life. A standard machine tool is a result of a continuous process of modification, addition and elimination. It is remarkable what a strong family resemblance there is between the machines which various makers offer for any particular class of work. A superficial explanation of this would be that the stronger makers set the fashion and the smaller fry follow. Some truth there is in this, but only a very small portion of the whole truth. In the place of almost every feature of existing types of machine tool, many alternatives have been tried and found wanting. It is getting increasingly difficult to design a machine tool which is a distinct break-off from existing types. It is practically certain that our standard types of machine tool today are the best possible types under present conditions, but it is equally certain that machine tools will continue to undergo modification to meet the changing conditions of work. An alert machine-tool maker rarely puts two successive lots of a particular design through his shops exactly alike. Some alterations, more or less important, will be made to improve each successive lot, and sooner or later the patterns and drawings will be abandoned and the machine totally remodeled. There is more than fashion in this. In engineering, as in most industries, the majority of changes made have for their ultimate object increased output. Other motives for change, such as increased accuracy, safety for work people and mere appearance, have also an importance of their own. With re-

gard to the latter point the writer's opinion is that the machine which is best fitted for its work—that is, which employs all its material to the greatest advantage—necessarily looks the best. Compactness or shop space occupied is generally a minor point in machine tools, but, other things being equal, is strong enough to decide a purchase. The improvements made and adopted are invariably based on practical experience, and no feature is embodied in a standard design without having been thoroughly tested.

To convince one's self of the real advance that has been made in machine-tool design, one has only to compare the output of a high-class machine of 1910 with that of its progenitor of twenty, or even ten, years ago.

ALL-GEARED MILLING MACHINES

One of the most highly evolved machine tools is the all-g geared milling machine. At least five different English makers are now on the market with these machines. They are expensive and complicated. From the nature of the operations performed the changes of speed and feed are made infrequently. Considerable time is necessarily taken up by changing cutters and setting up the machine for a fresh job. All these conditions seem to point out that here, on a milling machine, an expensive arrangement of mechanism for rapid changing of speed and feed has a doubtful chance of profitable employment. Yet, in spite of this, there is excellent ground for feeling confidence that the all-g geared milling machine has come to stay. The problem the purchaser of milling machines has to face is this:

will the increased output of the all-g geared milling machine pay sufficient interest on the extra price? The writer's opinion is that in shops where the machine can be kept fully employed the increased outlay in the purchase of an all-g geared milling machine will be an excellent investment. The great superiority of the constant power drive over the old type cone pulley drive from a countershaft, which had necessarily to be placed vertically over the machine, is a feature which will enable maximum cutting rates to be used throughout the full range of capacity of the machine. The feed range is entirely independent of the speed changes and both are positive. Thus the old trouble of the spindle-drive slipping while the feed continues can cause no further anxiety. The automatic lubrication of the bearings and loose wheels in the main transmission, which forms a conspicuous and excellent feature of most of the existing designs, will go a long way to enable the machines to spend a maximum proportion of their time in useful work and a minimum of time under repair. In fact, the sum total of the advantages offered by the all-g geared milling machines seems certain to ensure them a steady and increasing sale.

THE ENGINEERS' LUMBER-ROOM

In national and municipal politics we may agree to differ as to the advantages of conservatism and the evils of radicalism, but in business, and especially in engineering, there can hardly be any doubt that an enterprise which persists in being unprogressive is doomed. There is in many business men a reluctance to "scrap" an old machine, or an old system, or an old set of patterns, or an old design, long after these things have not merely ceased to be a source of profit but have become a positive burden. There is a class of engineer to whom one patched-up old machine gives more joy than would ninety and nine modern high productive tools.

Where the sale of manufactured

goods depends for the most part on value for money (a condition which is becoming almost universal) it is imperative that plant, staff and organization should be all of the highest efficiency. Undoubtedly there are occasions where the patching of old engineering clothes may be justified, but these are so few and far between that, in a general way, we may conclude that only a specially protected or monopolized market will permit of the use of old and patched plants and methods. It has to be reluctantly recognized that this kind of market is now scarce and getting scarcer.

A few years ago a catchword in the machine-tool trade was: "We take our own medicine;" and to show one's own productions at work in the home shops is a particularly strong argument to buyers. On the other hand, can there be a poorer illustration of lack of faith in the merits of modern machinery offered for sale than the use in their production of an old and obsolete plant?

There is another class of lumber persistently harboured by some engineers, greatly to their own disadvantage. Old side lines of odd and special machinery, all of them relics of the built-to-order days, come fairly under this description. The patterns and drawings are stored in valuable space which could be utilized to far greater profit; but hope springs eternal in the engineer's breast that there is still more money to be made from them. When odd orders are received for these machines they do infinite harm in interfering with the steady flow of work on the modern standard products of the shop, although perhaps on the books of the firm the transactions may show a profit. The issue and renewal of the old patterns and drawings make an altogether disproportionate demand on the pattern shop and drawing office. Such machines, if for the reason of their ancient design alone, cannot form a good advertisement for their makers (or for their buyers) in the shops where they are set to work. The writer has heard of

cases where sets of patterns have been used twice in twenty years, and then for single orders. Such transactions are, at the least, very astonishing.

The whole tendency of modern business policy is to carefully select such lines of machinery as can be most profitably produced in the home shops, and to strictly concentrate the attention of the manufacturing staff on these lines. Mixed orders for a general lot of machinery can be filled by buying other lines from makers who specialize in those particular machines. This combining of the functions of manufacturer and middleman may not be the final policy of the machine tool trade, but it is infinitely better than the old plan of trying to make at one works the whole range of machine tools. The day of building to order is gone. The swiftness of modern developments will not wait for machinery to be built. It must be stocked and delivered from stock. The sales department has no longer any direct dealings with the manufacturing shops, but only with the stock rooms. And is there any doubt that purchasers of machinery get far better value for money in this way than in the old way?

It may be recognized that there is a necessity for engineering establishments which will design and make to order odd machines, and it is also pretty certain that few machine-tool makers will close their books to an order for an odd machine if there is a reasonable prospect of a quantity being ordered later. But there are frequent inquiries for special machines with no prospect of quantities to follow. This condition may be met by an experimental department, which should have a practically complete plant of its own, so that the odd work which it undertakes will in no way interfere with the run of standard work. Perhaps not many firms would consider this experimental department worth while to maintain. In these days it is extremely doubtful if a concern of any size could live entirely from this odd and special class of work.

GOVERNMENT AND RAILWAY SPECIFICATIONS

Prominent amongst the relics of by-gone days to which the engineering world still gives house room are the cumbersome and elaborate specifications issued with inquiries for machinery by government departments, railways, etc. The original assumption at the back of these specifications was that the supplies of machinery were prepared to build to order. Most of them describe with a wealth of detail just how the machine is to be constructed and, in addition, provide for elaborate tests of the material used. Of late years many of these inquiries contain a clause stating that the tenderer may offer his nearest standard design, but must be careful to point out all the differences between it and the machine specified in the inquiry. All this causes a great deal of work in the estimating department and does not seem to be productive of any advantage either to the manufacturer or to the purchaser. The main points in the purchase of a machine tool are: (1) output, which depends on cutting power and ease of manipulation; (2) accuracy, and (3) cost. The relative value of the first and second points, output and accuracy, will vary with the nature of the work to be performed. Inquiries which specify a test of the machine to be made under maximum cutting conditions are undoubtedly in this respect on right lines, such tests being almost certain to show up any weakness of construction or inferiority of material that may exist in the machine. These maximum load tests have the same bearing on the machine-tool trade as racing has on the motor car or the bicycle industry; and the value of racing in the development of the motor car and bicycle cannot be denied. The tests will have an added merit if they are so arranged as to include manipulating the machine as well as merely making chips. Thus in a radial drilling machine a very good form of test which has been adopted by some government departments is to drill a large number of holes in a

piece of work in a given time, the holes to be arranged in a given order. This test of course involves, besides the actual drilling, all the movements the operator has to make in the ordinary working of the machine. The only difficulty about guaranteeing tests which include manipulation is that individual operators vary so much. A machine-tool maker, however, has always at his command men who are experts in the use of the machine he makes.

A common way of making up a specification for inquiry is to describe the machine which has really caught the official eye and then to disguise the description to a certain extent, so as to leave the tender open to competition as much as possible. This method certainly has the merit of fairness, but is often the means of inducing the less original and independent makers to copy the standard design aimed at and to undersell the original designer. It does not tend towards excellence for a number of machine-tool makers to be making at the same time practically identical machines.

A great deal of valuable time and energy would be saved to engineers if specifications were confined more to essentials, the purchaser being guarded by guarantees of output and maximum test performances. The latter, if successful, will pretty conclusively prove that material, construction and durability are up to requirements. If bearings, gears, shafts and framework behave properly under a maximum load test of, say, half an

hour (this of course entirely depends on the size and type of machine), there is good reason to believe that the machine will continue to behave rightly under ordinary working conditions.

THE FEED AND SPEED MAN

The position of "speed boss" or "rate fixer" is a comparatively modern one in engineering shops; and there is no position, as far as the writer is aware, which offers more difficulties. The conditions are such that the feed and speed man cannot conveniently be given direct authority over the work-people, and his relations with the various department foremen are extremely likely to be strained at times. The foremen are in the position of having to control men whose earnings are regulated to a great extent by the speed boss. The whole situation is full of the possibilities of trouble. In a particular case within the writer's knowledge, where the position of "speed boss" has been abolished and the piece rates are now fixed by the department foreman, work is carried on with less friction and with at least equal profit as compared with the abandoned system. Yet this idea of a works official specially trained in the work of fixing piece rates from observation of the actual operations seems too good a one to relinquish on slight grounds. There may be scores of instances of the successful working of the duties of "feed and speed man." So far, however, these cases have not come under the writer's notice.

DESIGN AND APPLICATION OF THE MODERN BALL BEARING

By J. F. Springer

III.—CONSTRUCTIVE DETAILS.

In the issues of this magazine for February and March the mechanical and physical principles involved in the use of ball-bearings for the reduction of frictional resistances were treated in accordance with the latest developments and practice. The present article, which concludes the series, discusses the practical applications of the scientific principles, and illustrates some of the approved details of construction.—THE EDITOR.

IN radial bearings the effects of centrifugal force are not of importance. With thrust bearings, however, it enters in such way as to limit the application of certain designs. In fact, 3,000 revolutions per minute is recognized as practically the speed limit for circular-groove thrust bearings. In order to understand the important rôle played by centrifugal force when speeds are high, reference should be had to the illustration. We will suppose the ball to be 2.375 inches in diameter, to weigh 2 pounds, and to be moving in a pitch circle of radius 7.5 inches. The formula for centrifugal force is—

$$F = \frac{\pi^2 w r n^2}{32.16 \times 900}$$

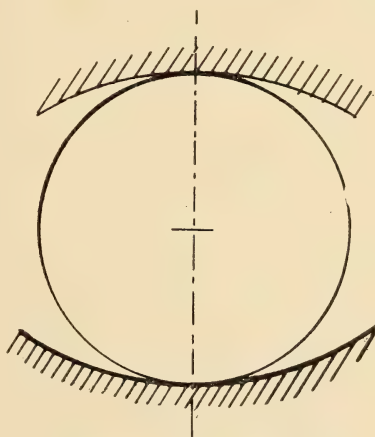
where w is the weight, r the radial distance of centre of ball in feet, n the revolutions per minute. We get

$$F = \frac{(3.1416)^2 \times 2 \times (500)^2 \times 7.5}{32.16 \times 900 \times 12} =$$

107 pounds.

We find, then, that, at the moderate angular speed of 500 revolutions per minute, the ball is pressed radially outward with a pressure of 107 pounds. It will be observed that this pressure of the ball outward is exerted against two inclined profiles, whose inclinations at the points of contact are zero. The inclinations increase as the ball forces its way outward, but for quite a space this is very slow. The result is that there

is set up a very strong lifting pressure. The ball will press outwards until load and upward pressure reach equilibrium. But this upward thrust may become very great. It will be noticed that n occurs in the formula in the form of a square, so that a doubling and trebling of the velocity will multiply the outward pressure by 4 and 9. With 3,000 revolutions per minute, the outward pressure will, accordingly, become 36 times 107 pounds. In such a bearing there may be 19 balls. As each ball is pressing outward with a force of 1.9 tons, the total outward effort will equal 36 tons. This is applied with great advantage against the load. It is easy to see that a tremendous axial pressure would arise against the load. It would seem possible to deal with this mat-



BALL IN CIRCULAR GROOVE

ter by means of a retaining cage, which should present surfaces resisting the outward movement. This cage would have to withstand the centrifugal force, but not the centrifugal force operating against gently inclined planes. The 36 tons would have to be borne. However, such velocities of the ball stream is seldom demanded. It should be remembered that the balls are only going at half the linear speed of the raceway circles of contact. As these have the same radius as the pitch circle of the balls, the angular velocity of the lathe will also be one-half that of the driving raceway. The tremendous pressure we have been considering apply, then, to raceway velocities of 6,000 revolutions per minute. All this seems a very interesting phase of ball-bearing design.

It will be noticed that separators are not necessary in thrust bearings as a means of accomplishing the assembling of parts. Further, the imposition of the load does not operate to reduce the size of the pitch circle and so crowd balls together. Nor is there the phenomenon of variation in linear speed because of variations in the radius of rotation. It would seem at first blush that the considerations which, with radial bearings, make us consider the contact of ball with ball as possibly important frictionally are here absent. But consider a moment. Ideally, all the balls in a thrust bearing are equally loaded at all times. In practice, however, we cannot count upon this. We should expect, then, that, with considerable speeds, areas of light load might yield more to the axial thrust arising out of centrifugal force. In this case a ball would here swing further out from the axis of rotation and so come under the influence of a higher driving speed. Its angular speed, however, would not be increased, as the angular velocity of the driver is everywhere the same. If, however, the inequality of loading should be

accompanied by a radial displacement of the centre, then balls on opposite sides of the bearing might be driven at different linear rates relatively to their radial distances. It would seem that the consequent crowding of balls might be prevented by maintaining in a positive manner the co-axial positions of the rings. The use of separators is, however, an alternative.

PRACTICAL APPLICATIONS

The use of ball bearings in bicycles has long been a familiar thing. In fact, this machine would probably never have become a real success without such frictional elimination. But the application to heavy loads or fluctuating carried under high speeds is quite a different proposition. But with the advance of engineering knowledge of the design and behaviour of ball bearings has come practical application to severe conditions. As an instance of this, consider the employment of the ball bearing to some of the most modern of marble-working machines.

In a certain recently-designed machine, marble slabs as received from the saws are given a smooth and true surface by means of a rapidly revolving grinding down. Carborundum serves as the means of cutting. The drum is $16\frac{1}{2}$ feet long, 16 inches in diameter, and has an angular velocity of 1,200 rotations per minute. This gives a peripheral speed of something less than a mile a minute. The slab is given a forward horizontal movement with the drum operating against its under surface. There is a rubber roller above the slab and corresponding to the drum, which provides a means of keeping the work against the grinder. The unfinished slabs often disclose a surface deviating considerably from a true plane. This gives rise to very uneven conditions as the slab moves along. The material itself is, besides, very fragile, and frequently has long cracks. It is probably because of the character of the marble

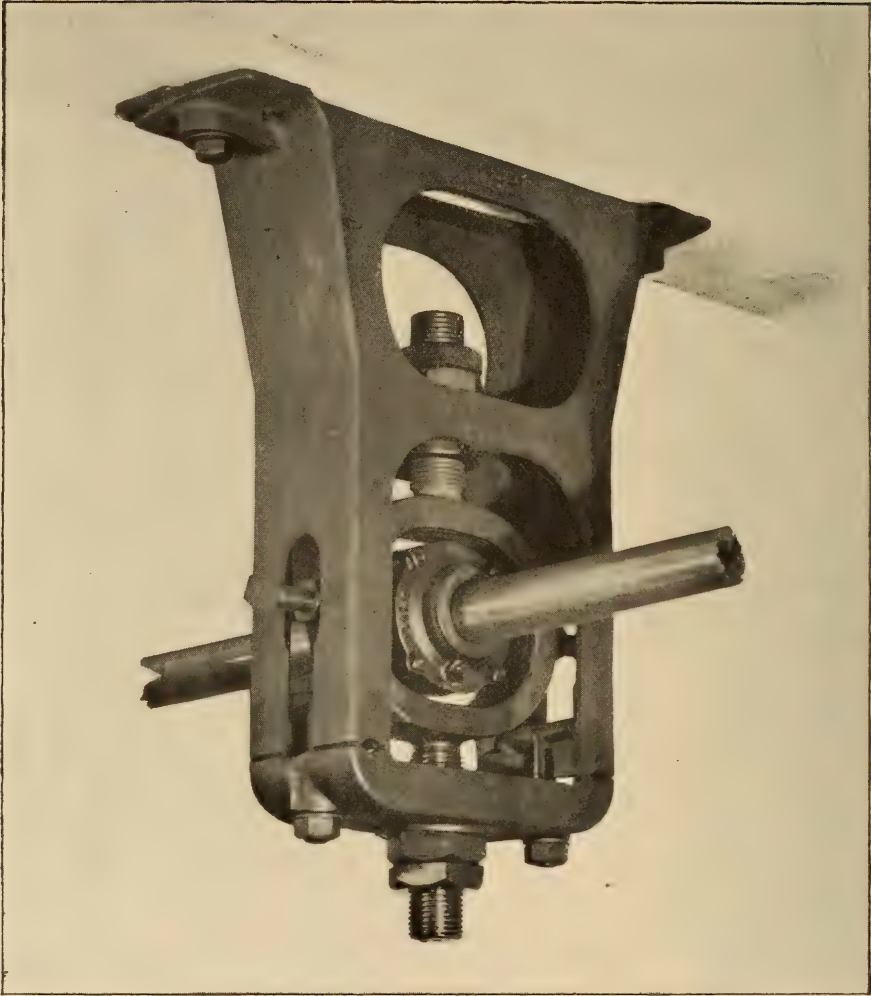
that the high cutting speed is necessary. Further, the work is continually flooded with water, so that grit, with water to carry it, is on the spot ready to ruin bearings. Now the matter kept in view in devising this machine was success of operation rather than economy of power. And it was the modern ball bearing which entered at this point and provided a means of accomplishing results that were despaired of in connection with the plain bearing. The journals of the drum were mounted upon ball bearings. It has been found practicable to surface from 800 to 1,200 square feet of marble daily and to operate without shutdowns. It is said that the vibration of the grinding drum was found to be less than 0.01 inch. The apparatus is electrically driven, the various speeds being secured by means of a tapered drum. There are in the drive quite a number of shafts, the most of which are turned by belt-driven pulleys. These shafts also were mounted upon ball bearings when their success in the machine itself became apparent.

The marble slabs are usually cut to size subsequent to surfacing. For this a machine was devised whose general appearance resembles that of an ordinary metal planer. The work is carried longitudinally by a suitable table. The cutting is performed by a carborundum wheel 12 or 14 inches in diameter, 5/16 inch thick, and rotating at a speed of, say, 2,000 rotations per minute. The transverse cuts are made by operating the head containing the grinding wheel across the bed. The spindle here was mounted on ball bearings and operated with success. Further, the power transmission from motor to head was also effected by shafts mounted upon ball bearings. Efforts had been made previously to employ carborundum wheels for this or similar service, but without success. But success was realized in this instance, and is attributed chiefly to the accuracy with which the grind-

ing wheel may be run not only at the beginning, but indefinitely. Shocks due to uneven running are thus eliminated. It has been stated that these cutting wheels, when mounted on ball bearings, have a life of three or four days. To secure high accuracy with free running in connection with plain bearings, it would seem necessary to employ a very considerable effective length of bearing, whether the length of actual contact is large or not. With a spindle properly mounted on ball bearings, the total longitudinal space is reduced to a comparatively small amount.

Of still other marble-working apparatus we mention only a set of four rubbing machines. There is a large cast-iron plate, 14 feet in diameter, mounted upon a vertical spindle. The work, which might amount to 3,000 pounds, is carried on this plate, and thus revolved at the rate of one turn per second. There seems some confusion as to the total weight carried by the thrust-bearing which carried the vertical spindle upon which the plate is mounted. However, with a full load it is at least 7½ short-tons. It appears that the ball thrust bearings used on these machines were supplied under the impression that the loads to be carried were but 20 to 25 per cent. of what they actually were. Nevertheless, these bearings, thus grossly overloaded, seem to have given trouble only in connection with one of the raceways.

At the plant where these machines were installed the line shafting was also supplied with ball bearings. But this is not merely an incidental question. The use of the ball bearing for such purposes is a field to itself. It has been found in practice that the very perfection of the bearing itself was a source of faulty installation. By using an ordinary form of hanger a line shaft may be so fitted with ball bearings as to be rotatable by hand through the agency of, say, a 2-foot pulley. But



SPECIAL HANGER FOR BALL BEARING

a test such as this, though sufficient, perhaps, with the ordinary plain bearings, is entirely inadequate with ball bearings. The shaft in ordinary cases should be rotatable by hand, without the use of the leverage of the pulley. The shaft may be kinked in one or more places, or the boxes may be out of strict alignment. The shaft can be turned with the pulley, because the bearings themselves are so frictionless that nearly all the resistance is that which arises out of the slight bendings of the shaft. Mr.

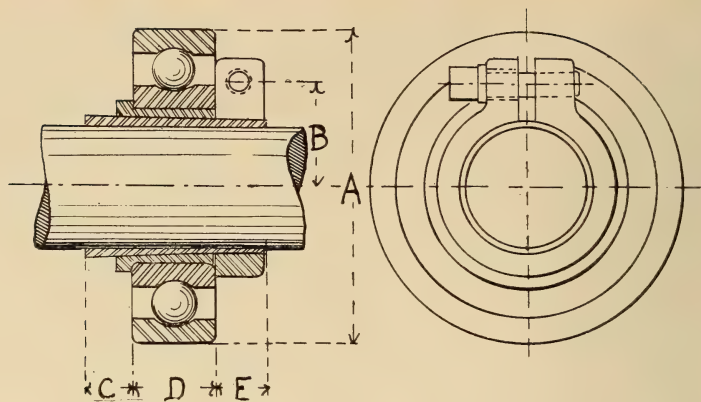
Ed. J. Baechle, to whom the writer is indebted for much of what is here told in connection with line shafts, regards the ordinary hanger as entirely unsuitable for use with ball bearings. What has been needed is a hanger which should admit of the box which carries the bearing itself being adjusted vertically, horizontally and angularly in every direction. It is also necessary that, these adjustments once made and the parts locked, the conditions should remain fixed. In the illustration is

shown a special hanger, for which a patent has been applied, which is designed to fill the requirements. The frame, including the cap at the bottom, is cast in a single piece. Strength and lightness are secured by the channel section adopted. It is very necessary that vertical adjustment shall take place along a single straight line. The yoke which is seen in the figure enveloping the bearing box is provided with two vertical arms threaded co-axially with each other. These pass through bored holes in the cap and the strut of the frame. In order to provide a bearing surface on the threaded arms, the acme thread, with its flat top, is used. The holes are bored and the seats for the nuts faced by one and the same boring bar, a jig being used to hold the frame in position. When these holes and nut faces are thus secured in exact relation to each other the cap is split off with wedge chisels. Irregular surfaces of contact are thus obtained, which guarantee exact replacement. The cap is held in place by two straddle bolts. One of these is seen to advantage on the right. The yoke may be adjusted vertically for two inches and to any angle on a vertical axis by means of the hexagonal nuts. The yoke is bored and tapped on its horizontal axis. Screws are passed through these and provide at their ends journals upon which the bearing box may be swung by providing suitable recesses. By suitably moving these screws the bearing box may be adjusted 1 inch horizontally. It will now be understood that very considerable adjustment vertically, horizontally and angularly may be secured and the positions rendered fixed. The bearing box will be free at all times angularly on a horizontal axis. This freedom permits varying vertical strains on the shaft itself. The box consists of a cylindrical shell in which the bearing is installed with a sucking fit. At each end a convex cap is secured by suit-

able bolts. If the box has an intermediate position on the shaft, the caps are alike. Where the shaft passes through the fit is quite close, about $1/64$ inch being total clearance allowance. The hole wall in the cap is recessed annularly. This space may be filled with felt or similar material. There is sufficient space within the box to receive a year's supply of lubricant.

It is desirable to secure the bearing itself firmly to the shaft. Of course, it cannot be driven on except when its position is to be at or near the end. And even here such a mode of installation would be objectionable. In general, the bearing must have a bore whose diameter is larger than that of the shaft, to facilitate installation and removal. There are a number of methods of accomplishing all the results desired. A means employed by one of the principal concerns is shown in the illustration. In the axial section on the left a flanged sleeve is seen fitting the hole of the bearing with a thoroughly tight fit and providing on one side an abutting flange. Interiorly, this sleeve has a conical surface. There is a second sleeve having a longitudinal slit and a conical exterior corresponding to the hole of the first sleeve. By means of a split nut, seen in transverse elevation on the right, the bearing, together with its flanged sleeve, may be driven to and fixed in a position where all the pieces are firmly secured. The inner raceway may be made with a tapered hole at the outset, when, of course, the solid sleeve would be unnecessary. By this means the shaft is not marred, and entire disassembling is readily secured. It will be noticed that the revolving circuit of balls performs the duties of a ring oiler, only more effectively, because of the irregularity of surface.

It is said that line shafting fitted with ball bearings have been in satisfactory use for many years. In one of the ball-bearing plants it



Shaft Dia. in inches	A		B	C	D	E	Load lb	Bearing weight lb.	No of Bearing
	mm.	inches	inches	inches	inches	inches			
1 5/16 M	72	2.8346	0.8125	.375	0.75	0.53125	850	0.95	306
	80	3.1496	0.9375	.375	0.83	0.420	1100	1.24	307
1 7/16 M	100	3.9370	1.3125	.375	0.98	0.379	1750	2.21	309
1 11/16 M	110	4.3307	1.5000	.375	1.06	0.534	2100	2.86	310
1 15/16 M	120	4.7244	1.625	.375	1.14	0.447	2400	3.67	311
2 3/16 M	140	5.5118	1.875	.375	1.30	0.528	3300	6.05	313
2 7/16 M	160	6.2992	2.125	.375	1.46	0.509	4400	8.81	315
2 11/16 M	170	6.6429	2.3125	.375	1.53	0.595	5000	10.44	316
2 15/16 M	180	7.0866	2.4375	.375	1.61	0.640	5700	12.30	317
3 3/16 M	190	7.4803	2.4375	.375	1.69	0.6537	6400	14.17	318
3 7/16 M	215	8.4645	2.625	.375	1.85	0.681	7700	17.24	320
3 11/16 M	225	8.8582	2.3125	.375	1.93	0.726	8400	22.03	321
3 15/16 M	240	9.4488	2.875	.375	1.97	0.7125	10 000	27.77	322

DETAILS AND DIMENSIONS OF BALL BEARINGS

seems that line shafting mounted on ball bearings has been in use for five years and that no wear is apparent.

But the great questions which relate to this matter are economic ones. It appears to have been thoroughly demonstrated from actual experience that the modern ball bearing of high-grade construction and design is applicable to line-shaft conditions. This pudding has been eaten. There are, however, other questions which enter subsequent to demonstration of practical applicability. Ball bearings con-

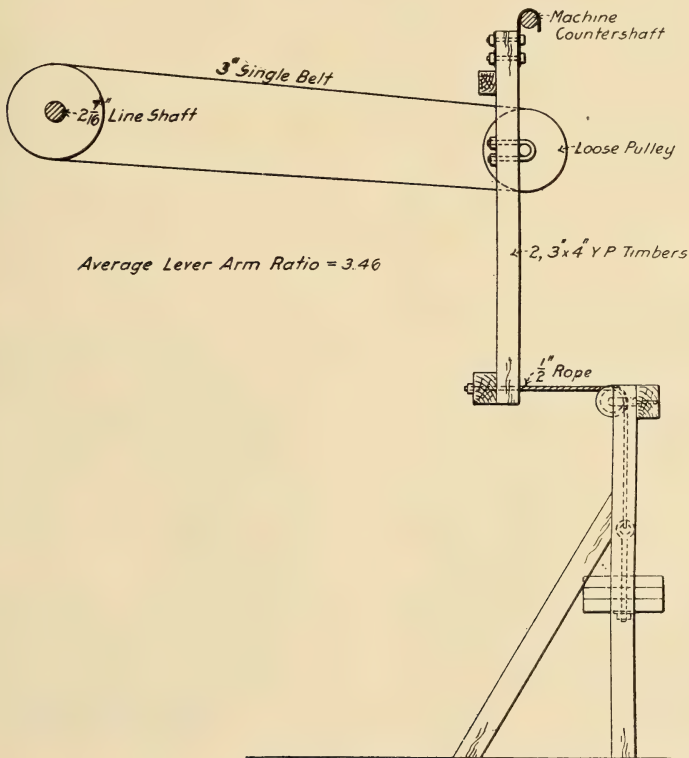
structed of the best materials and to marvelous accuracy are, in general, more expensive from the point of view of first cost. The hanger costs more, the bearing itself costs more. Two questions, therefore, arise, How do the two bearings compare as to efficiency? How do they compare as to life? There is a story told of a lawyer who began to give twelve reasons to the judge for the non-appearance of his client. "In the first place, Judge," said he, "my client is dead." The judge here interrupted with, "Never mind about

those eleven other reasons." Well, so it may turn out in connection with comparative efficiency and comparative life. The difference in efficiency may be so marked as to enable us to dispense with answering the question as to life.

It seems that the comparative efficiencies had never been tried out under shop conditions until Mr. Henry Hess, of the Hess-Bright Manufacturing Company, Philadelphia, requested Messrs. Dodge & Day to determine the point. It will be instructive to consider in a broad way the tests and results.

A line shaft, 72 feet long, 2 $\frac{7}{16}$ inches in diameter and supported by ten hangers, was employed. The intervals between supports were thus, on the average, about 8 feet. This shaft was driven at one end by a 10 horse-power electric motor. In

order that the tension of the belt effecting the drive might be constant, an intermediate pulley loaded with a constant weight was interposed between motor and shaft. Suitable precautions were taken to insure a constant angular velocity of the shaft of 214 revolutions per minute. In the eight remaining intervals between hangers were eight pulleys. These drove, by means of belts, eight other pulleys mounted loose and in such way as to maintain determinate tensions on the belts. In the diagram we have a diagrammatic representation of the loose pulley arrangement. The loose pulley is supported on a dead axle secured to a swinging frame. At its lower end this frame may be put under a definite horizontal stress by means of the rope, guide pulley and weight. In this way the belt connecting the line shaft



APPARATUS FOR TESTING BALL BEARINGS

and the loose pulley can be put under a definite tension. All of these belts were placed on the side of the shaft opposite the motor. In the several hangers were used alternately plain ring-oiling babbitted boxes and ball bearings. The ball-bearing boxes were placed on the shaft conveniently near the hangers, so that it was not a difficult matter to replace the plain bearings. The conditions of the two arrangements could thus be made precisely the same except for the shaft bearings. In all, a series of eight tests with plain bearings and a duplicate series with ball bearings were made, each test lasting for 40 minutes. The loads imposed ranged from 126 to 662 pounds per bearing.

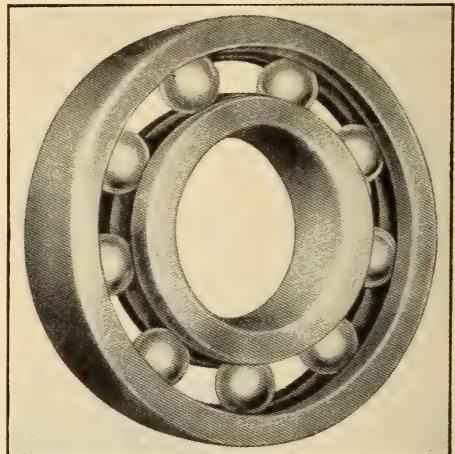
As the babbitted bearings were 10 inches long, this is a pressure per square inch of projected area varying from 5.2 to 27.3 pounds. Each ball bearing contained twelve balls of 9/16-inch diameter. It would seem probable that each ball went under nearly the full load corresponding to its bearing. The belt tensions ranged from 20 to 90 pounds per inch of width. It will be noticed that only about 50 per cent of the journals, if we regard the whole apparatus, could be supplied with ball bearings. With the lightest load, the saving in power was 14 per cent. With the increased loads of the next three tests, the saving was 29, 36 and 35 per cent. With the next two, where the belt tensions were 70 and 83 pounds per transverse inch of single belt, the saving decreased to 25 per cent. The maximum savings of 36 and 35 per cent. were made with the belt tensions ranging from 44 to 57 pounds, consonant with good practice. A very high percentage (65 per cent.) of saving was realized by running the shaft with the loose pulley belts off.

Now it is not difficult to see that, with a power saving of 35 per cent. effected by the "jeweling" of the line shaft, the actual life of the bearings becomes a very subordinate factor.

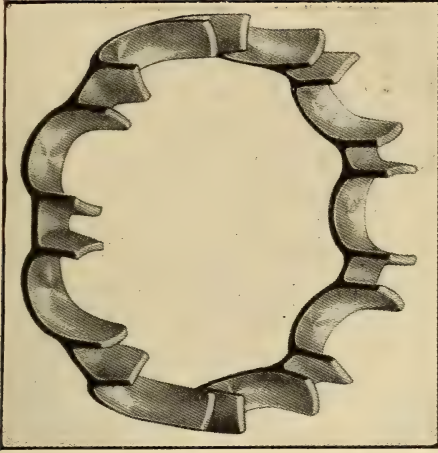
Power is what costs money, and a one-third reduction is an enormous matter. However, the life of the ball bearing is a prolonged one, these, as previously noted, having already endured five years without appreciable damage. The elimination of attention and reduction of oil consumption are other incidentals to be put upon the credit side. In the present instance but two oilings had been made in the five years prior to the test. One of these oilings was immediately consequent upon a shop removal. Instead of ball bearings in such situations requiring skilled and frequent attention, the best attention that they can be given, so it seems, is to let them alone.

It may be as well to remark here as to an idea which has gained some prevalence. It is thought by some that ball bearings require no oiling. If perfect spheres were rolling in perfect raceways without compression of parts such an ideal condition might, perhaps, result. Real bearings require oil for the minimization of frictional conditions. It is also needed as a protection against corrosion.

The application of ball bearings to machine tools is an important development. This development is probably further along in Germany than



BALL BEARINGS READY FOR SEPARATOR



SEPARATOR FOR BALL BEARING

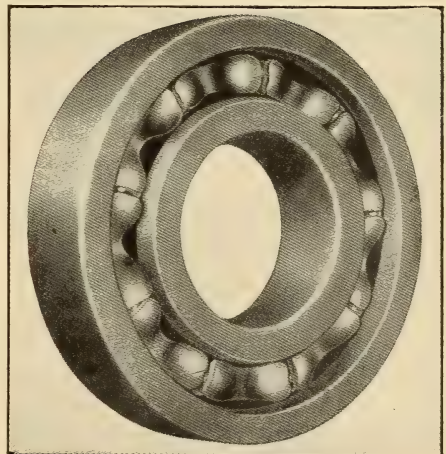
elsewhere. But we are surely and rapidly advancing. However, in many of the instances cited in the sequel German practice is drawn from for illustration. The writer is indebted to the Hess-Bright Manufacturing Company for much valuable assistance.

In the illustration we have a partially disassembled two-point bearing. The raceways are solid, and have circular grooves approximating the balls in curvature. The bearing is but partly filled with balls, to permit assembling. The separator is placed in position from one side, when the projections may be bent over, enveloping the balls. If any tendency to crowd occurs, the elasticity of the separator accommodates it for the moment it exists.

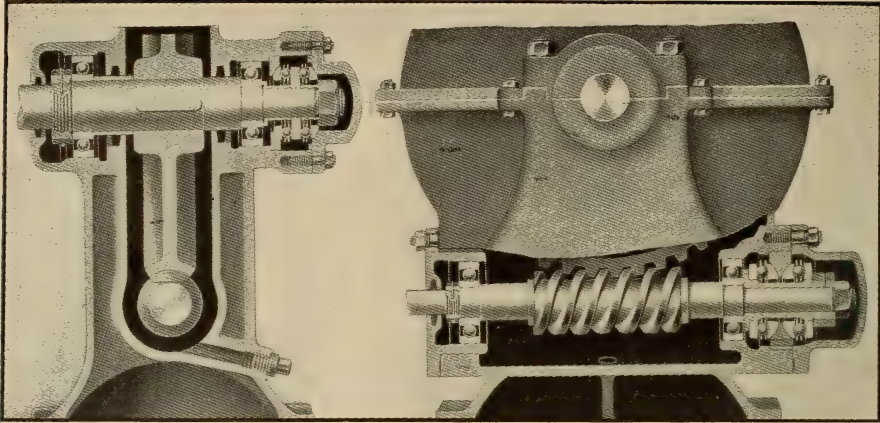
In the drive of turning lathes and the like it is necessary to provide both for radial and axial loads. In the illustration we have two radial bearings arranged far apart on the spindle. In this way exactness of alignment is secured. On the right will be seen together two thrust bearings. One washer of each has its outer face spherical. This is seated against a corresponding recess in a removable collar seen between the two bearings. The axial thrust may be taken in either direction, only one

bearing being involved. The radial bearings escape such stresses, as their outer rings have a loose fit in the housing. However, these thrusts are transmitted through the inner rings of the radial bearings, as may be seen by an inspection of the figure. It will be observed that from right to left the diameters corresponding to the three bearing installations diminish. In this way the radial bearing may be installed without the use of sleeves in their bores. The spindle is not marred, except on threaded portions. Here nuts are locked in the manner shown. The thrust from left to right is, as will be seen, transmitted by a long sleeve. The spherical seating of the thrust bearings accommodate slight variations in alignment.

The grinding machine presents a number of difficulties. The spindle must be rigidly and accurately maintained in position. It must be run sufficiently free to permit of high angular velocities. The particles coming from the grinding wheels are grit of the very worst description, and, consequently, destructive of bearings. In the illustration we have the ball bearing applied to the grinding machine. The annular grooves in the boxes, where felt or similar material may be maintained, are in plain



BEARING COMPLETE WITH SEPARATOR



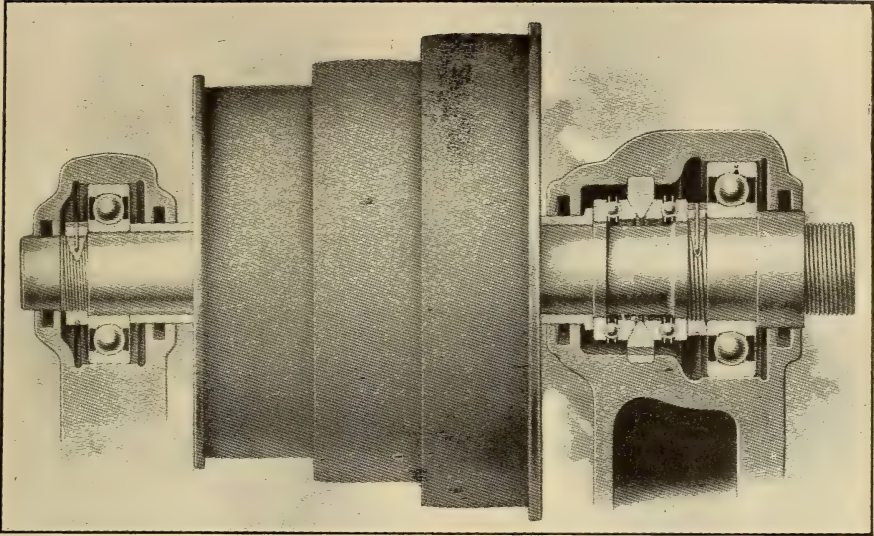
BALL BEARINGS FOR WORM GEARING

view. The high-grade ball bearing is itself almost without radial play. Here even this may be minimized by the wide separation of the bearings. Here both races of each bearing are secured from longitudinal displacement, contrary to general methods of installation. One reason for the sucking fit with the outer raceway is that, with a rotating shaft, it permits a creeping of the ring and a consequent distribution of wear of the raceway groove. Here the load is a light one, and this more or less loose fit may be discarded and decreased radial play obtained.

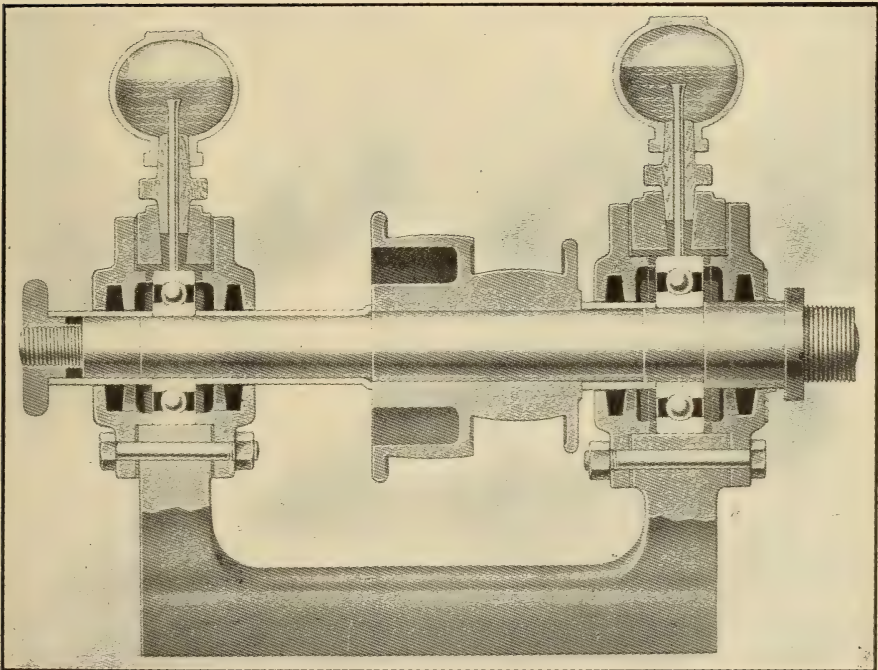
If one stops to consider the relations subsisting in a worm and gear, he will readily see that the worm is subject to a severe axial thrust. If the movement of the apparatus is reversed, then this thrust will occur in the opposite direction. In the example shown the double-thrust bearing is mounted at one end of the worm spindle upon a sleeve which provides an abutting surface for the inner ring of one of the radial bearings. This sleeve is secured in part by a nut on the spindle. There is a lock-nut on the sleeve, which operates to unite both thrust bearings and the intermediate collar in one piece. In fact, by removing the cap and the nut on the spindle the double-thrust bearing may be removed alto-

gether with the collar. It will be noticed that the radial bearings are so mounted as to permit a longitudinal movement between their outer rings and the housings. By using a sucking fit here all axial thrusts will be carried entirely by the thrust bearings. The section shows the gear spindle and its bearings. When the worm drives, its pressures are not delivered perpendicularly to the axis of the gear spindle. There is thus exerted an axial thrust in both directions if the apparatus is reversible. The radial bearings are mounted much the same as before. But the arrangement of the double-thrust bearing is quite different. The intermediate collar now projects inwardly. It is secured to the shaft with the aid of a couple of sleeves and a nut. This double-thrust bearing is not self-contained, as a brief examination of the figure will make clear. The spherical seats are also quite differently arranged in the two cases.

It will be noticed by the attentive reader that the examples show a division of the radial and axial duty between two radically different classes of bearings. It is quite true that there are special cases where the thrust duty is so light that it seems undesirable to employ a special bearing to perform it. But, in general,



LATHE HEAD WITH RADIAL AND THRUST BEARINGS



BALL BEARINGS FOR GRINDING MACHINE SPINDLE

the great difference in direction of the axis of a ball's rotation introduced by imposing the load, now axially, now radially, affects seriously the frictional conditions resulting from compression. That is to say, if the relations of the raceway profiles to the ball fit them for carrying a radial load they are almost certainly unsuitable for an axial load. Similar remarks apply where a bearing is designed to carry both loads

simultaneously. As the matter now stands, it is the writer's opinion that, where the duties are at all severe, there should be a complete divorce of the mechanical means for sustaining them. In general, a correctly designed radial bearing will be injured if subjected to severe radial conditions. The radial bearings should, therefore, be so designed or installed that it will never feel the axial load.



STORE PLANNING

THE CIRCULATION OF HUMANITY A PROBLEM IN PSYCHOLOGY

By Charles D. Seeberger

It is now beginning to be realized that many undertakings which were formerly given but scant preliminary consideration are really an important portion of the work of the engineer. Nearly all departments of municipal engineering relate to the provision for the convenience and regulation of large numbers of people, while the installation of stairways, elevators, escalators, and passages, together with the design and location of doorways and windows, and the best utilization of space—all these elements are now conceded to form engineering features demanding the ablest expert knowledge and the exercise of trained judgment. Mr. Seeberger's discussion starts with the fundamental element of the mental attitude which may be guided in both individual and crowd, and his examination leads directly up to the points which must be considered by the engineer as carefully as the laws of mechanics and the nature of the other materials upon which he has to work.—THE EDITOR.

THE success of a store depends both on its merchandise and on its methods. The full measure of success is to be attained only by so arranging the premises as to bring the largest possible display of merchandise under the eye of the customer, thereby both satisfying his immediate wants and suggesting other wants to be supplied, either on that occasion or on some other later visit induced by this suggested want.

Only a small proportion of the customers confine themselves to the purchase of merely and exactly the articles they come to buy. Even the most determined customer can be induced to examine a range of goods in the desired line, and the intelligent salesman endeavors to lead on toward articles it is most desired to sell, and thereby suggests wants. The store deals with a large class which not only sees but is willing to inspect all the various displays, so far as this can be done without conscious effort.

Let us reason from analogy. For example, we visit a picture gallery and come away without a clear recollection of the number of rooms visited, having been led from picture to picture and room to room without conscious effort. If we stop to think of it, we will find that the only pictures we recall having seen are those hung "on the line," for the eye is lazy and disinclined to exert itself

for any beyond the most convenient display. We are not conscious of this, for our subconscious control leads us through the galleries, as it does on the street and in the performance of the many daily acts of life. What we are conscious of is the picture our eyes let us see, and, after exerting this conscious mentality for a certain time, the supply of energy is exhausted; we are tired, and leave before we have experienced mere physical fatigue incident to the actual progress through the gallery under our subconscious guidance.

Now let us imagine that our progress through the gallery is made under circumstances causing alarm, such as knowledge that there are openings in the floor unguarded, or it is otherwise unsafe; a great crowd; a suggestion of fire; and immediately all our faculties are centered on our progress; we no longer trust to our subconscious control, but employ our active mentality for the commonplace acts of walking, dodging our neighbour, and the like, yet trying to see the pictures at the same time. After a very short interval we find ourselves worn out, and without a recollection of a single picture.

In arranging a picture gallery we will grant that it should be so ordered that progress through it is accomplished by subconscious control, and that the pictures be placed where the eye sees with the least effort—

experience tells us where—and this is the origin of “on the line.”

For the merchant the problem is no whit different. The customer should move through the store under subconscious control, and the active mentality should be reserved for the inspection of merchandise. The more nearly this is attained the greater will be the sales. The average brain is capable of but a limited effort, and, if its energy is consumed by active mental effort in merely progressing through the store, fatigue intervenes to stop buying, the customer goes home without a recollection of the displays, and the merchant is the loser not only from this, but also, perhaps, from a prejudice engendered by the fatigue.

Consider the subject of store planning as an engineering problem! We find the first and great factor to be a recognition of subconscious control, and if we can successfully marshal the other factors we have the data which would enable us to circulate humanity with the same precision we now do electricity.

Reasoning from our experience in the picture gallery, we know that complete subconscious control is dependent upon ample space and freedom from interference with progress; and, accordingly, the aisles of the store must be commodious, and if the displays are pleasing we may expect a large part of the daily audience to find its way to the rear of the store.

Nothing should be interposed in the aisles, such as fixtures and bargain tables, because they interfere with free progress under the subconscious control, and, when they serve to congest the aisles, they call for active mentality. We realize that, while the bargain table enables one to sell many times the quantity of that commodity than would otherwise be sold, it entails a conscious effort on those making the progress of the aisle, to the loss of the possible maximum of business; therefore, we shall seek to locate the bargain lines in some space not attended by this effect,

and where the bargain-hunter will be relieved of the distraction, caused by others not interested in the bargains, working their way through the crowd around the tables when placed in the aisles.

The width of the aisles will be proportioned to the anticipated numbers, not wider than necessary, and not all of the same width; because, having laid out the store theoretically, before the architect has made his detailed plans, we can see to it that the column centres are such as to accommodate the plans for aisles and fixtures to the best advantage. We have in mind always that sales are in proportion to the extent of display coming under the eye of the customer. For convenience, let us assume we are now dealing with one composite customer, who represents the average of all as to stored mental and muscular energy with which to resist fatigue, and who traverses the average distance through the store and sees the average amount of displays. It is possible to ascertain in any store approximately how far, in feet, the composite customer traverses the building; and it is probable ere long that in great establishments such data will be regarded as of sufficient value to justify the expense of collection, because it would enable the management to place the various departments with certainty of results not possible now under “cut and try” methods. Another factor of the problem is to endeavor to make all parts of the floor of nearly equal value, which is the same as saying that the customers be distributed nearly equally all over the floor. If any one part of the floor is to have more customers than another, we should prefer to have it at the rear of the store, as this means the greatest extent of progress through the store, and, consequently, the greatest extent of display seen. Furthermore, there will be no exits to suggest leaving, as is the case at the front of the store. Our efforts are thus all to be bent on getting the

customers to the rear of the floor; and, therefore, the prominent aisles all lead through to the rear without jog or jut of fixtures, the cross aisles being ample, but not conspicuous. At the rear the space and fixtures are so arranged as to lead the customer to the right or left, so as to insure departure through another aisle than that of entry, thereby doubling the display brought under the eye.

As in the picture gallery, so in the store, we arrange the displays "on the line"; and this means the fixtures should be low; thereby glimpses of displays on adjacent aisles will occasionally strike the customer's eye and serve immensely to educate the customer as to location of departments which we have arranged in the logical sequence of the average wants of the composite customer, because we can readily obtain the data which would enable us to do so. We realize the importance of a continuous progress or circulation without retracing steps, and, consequently, appreciate that the location of the doors of ingress and egress—which, of course, we endeavor to keep separate—is a matter of prime importance. Fortunately, exact data may be obtained for this purpose, and, furthermore, we are not bound by the old, preconceived idea of major and minor axes of the premises and the balancing of architectural features, which are seen on looking at the plans, but seldom observed afterwards in the building itself. The data which enable us to locate the doors also tell us which is to be the main aisle, consequently the starting point from which we lay out the departments.

So far we have treated the store, like our picture gallery, as a single floor of indefinite extent; but it is not to be supposed that we intend to impress our customer by its size on first glance, for that would inevitably suggest fatigue, discourage the attempt to examine the displays, and lead to taking no more than a cursory view of the displays, without leaving

a lasting impression of any of them, just as would be the case were our pictures hung in a vast amphitheatre where we would feel there was neither beginning nor end, making the task imposed so far beyond our strength as to make even an effort to see any of the pictures useless. Furthermore, we are beginning to believe that our civilization is approaching the day when mere bigness will cease to be a criterion, but, on the contrary, regarded as an evidence of ignorance of the art of preserving a certain relation to the human factor, which, in the case of our store, is the chief one. Consequently, our architectural features will be varied from one part to another of the premises; here and there pavilions will be found devoted to merchandise, flowers, rest places, as the case may be, not interfering with the aisles, but serving to suggest delimitations and sections in the store, analogous to the rooms of the picture gallery, but with the store atmosphere pervading unbrokenly everywhere.

The limitations of land area prevent an ideal store on one level, but the deductions we have made will apply broadly to a building of many floors; so let us see what new features are introduced by the attempt to utilize other levels.

Going back a couple of generations, we find the second floor, reached by stairs, was found available for sales purposes, and, a generation later, the merchant prince of that day introduced a new device—the elevator—contrary to the advice and against the opposition of all his advisers and managers, who argued that the elevator was adapted for a hotel, after they had seen it in one, but was unsuited to a store. Such is the attitude of mind toward radical improvements. The result was that several additional floors were available for sales. At this time the basement was regarded merely as a cellar, fit for storage, packing boxes, etc. Then came a merchant of the present day, gifted with an imagination to an

unusual degree, who recognized—though, perhaps, not in these terms—that the customer was guided by subconscious control, and argued that the lack of effort in going downstairs would appeal to the subconsciousness, and that the glimpse of displays seen at the foot of the stairs would lead customers to the basement, notwithstanding the low ceiling, the imperfect ventilation and the absence of daylight. This merchant has lived to see not only a daily attendance on a basement floor ten or a dozen times greater than that on the average floor above the first, but also to see his discovery copied by practically every store in the land. The real gist of his discovery was that subconscious control leads us to do the easy thing first (namely, going downstairs), without reckoning with the next problem, which was, of course, getting out of the basement.

Were the subconsciousness a reasoning faculty, it is obvious, because the muscular effort would be about the same, it would have led to the second floor, with its better space, ventilation and daylight. If our picture gallery has assisted us in reasoning thus far, perhaps we may profitably carry it still further and make deductions of value in considering our problem of utilizing the upper levels in a manner comparable with the ground floor. Let us assume that the various rooms of the gallery have their floors pitched at a slight angle, so that, in traversing the series of rooms, arranged around a square, perhaps, we find ourselves at a considerable elevation above the point of entrance. This would involve an effort at which our subconsciousness would rebel, and also exhaust our physical energy; for, of course, it takes just as much energy to walk up an incline plane to overcome a certain height as it would if we employed stairs, but with this difference, that flexing our ankles and the relatively untrained muscles makes it more difficult to sustain the prolonged effort on an incline. Let

us, therefore, imagine some outside agency, such as a slowly-moving floor, to be invoked to make the experience in such a gallery exactly the same as before.

Under this assumption we would see, enjoy and carry away a recollection of the pictures, as before, and there would be no break in the continuity of the display, and throughout we would be in the atmosphere of the pictures, which, of course, we assume have been so skillfully arranged as to hold our interest unceasingly.

We can see nothing in this assumption inapplicable in nearly the same degree to a store, for we know that stairs are an equivalent of an inclined plane and that elevators and escalators are analogous to the moving floor we have imagined, provided we use sound judgment, based on obtainable data, as to their location; for they must be perfectly placed and treated so artistically that they merge with the features which we have designed to dwarf the feeling of bigness. Likewise the stairs, which perform a great function—greater than most merchants realize (though it is not our wish that the energy of our customer be expended on them)—must be given suitable locations. The escalators and stairs meet a most important requirement admirably, as on them the customer is always in the “atmosphere” of the store, and the display is never interrupted. Elevators are not so fortunate in this respect, for in their shafts there is no store “atmosphere”; and, furthermore, they may short-circuit, so to speak, the display, by taking the customer from the first to the top floor, without a view of the display on the intervening floors.

Our visits to the picture gallery are of varying length, and if we were interested in following up the matter we would find that, after a number of visits, we had visited some of the rooms only occasionally, while others—those we first enter—we have visited repeatedly. The capable manager would recognize this fact and be

apt to place the pictures he believes we most desire to see in the rooms most frequented, taking pains, however, to have all the rooms interesting. He would probably find the attendance at various rooms inversely as the remoteness—the greater the distance of the room (the greater the demand on energy), the less the attendance.

We also would expect the same in the store for which we are planning to promote an ideal circulation; and, if we are so fortunate as to secure an

attendance of customers on the various floors which could be represented graphically by the figure of a cone drawn with its base on the first floor, the apex through the top floor, crossed by lines drawn to represent the floors between, and the intersection at any floor, when read by scale, is found to be proportionate to the known attendance of this floor with reference to the first floor taken as unity, we probably have attained perfection of circulation and the maximum advantages to be derived therefrom.



THE PORT OF HAMBURG

By G. A. Waterman

MORE steamship services converge on Hamburg than at any other port, making of this inland harbour the world's great marine clearing house. Were the ordinary docking facilities of other ports employed here, the congestion of shipping would long since have checked its development. By the application of every conceivable form of time and labour-saving machinery on an unprecedented scale the port of Hamburg has become the model harbour of the world. More than \$100,000,000 has been expended in perfecting the harbour, and a further appropriation of \$50,000,000 has recently been made to develop Hamburg into the greatest shipping port in the world.

Some twenty million tons of freight were handled in the port of Hamburg last year. Although the harbour at no point approaches the width of that of New York, the docking space is so systematically arranged that an

enormous fleet of merchant ships are continually arriving and departing without confusion. The vessels enter the great docks, some of which are 2,000 feet in length, under their own steam and require very little assistance from the tug-boats. Continuously along the line of the docks the most modern machinery for handling freight has been installed. The trunk lines of the railways, parallel with the dock front, run to the foot of the piers.

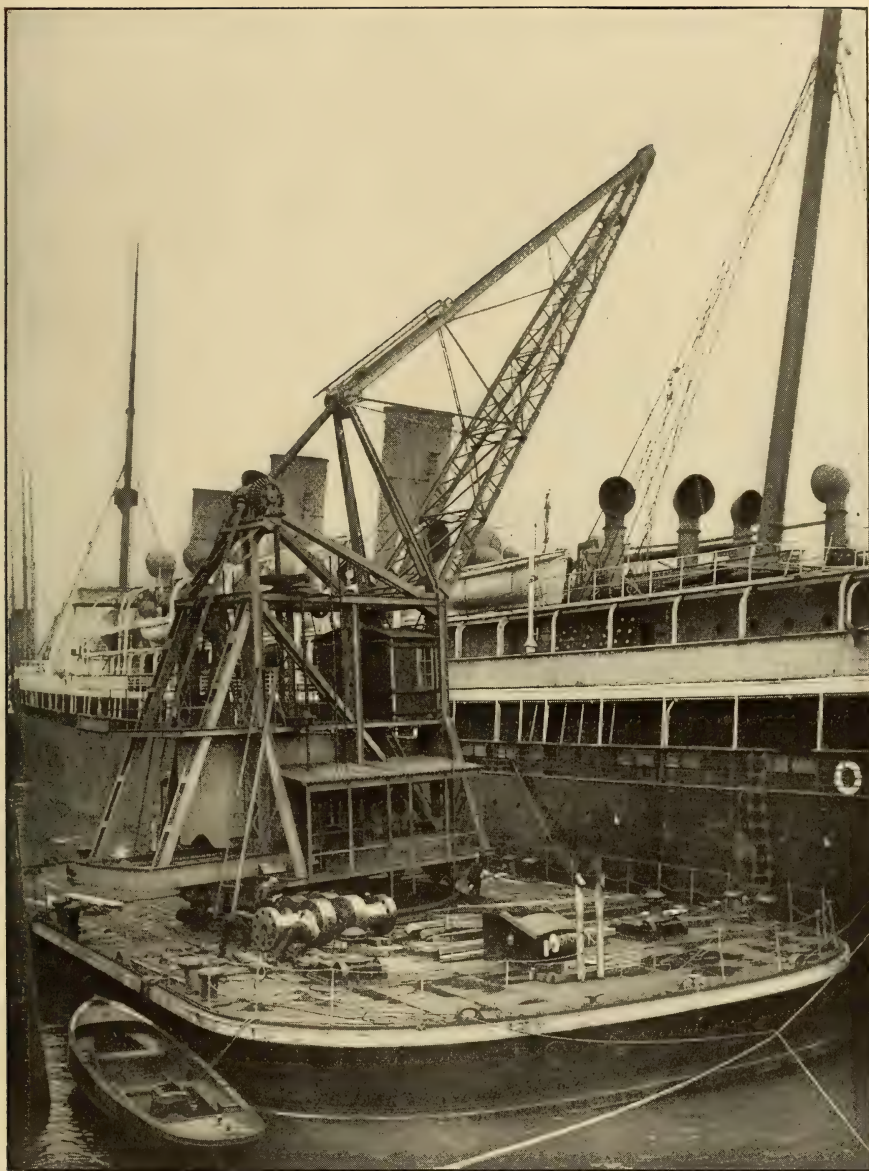
Powerful electric cranes are available at every point. At the entrance to the Hamburg-American docks stands a crane capable of handling 75 tons weight, while other cranes of 10 or 20-ton capacity slide along the railways, and may be brought into position alongside of any boat in a few moments. To economize space, which is so valuable, some of the electric cranes travel along elevated structures, thus leaving the



TRAVELING CRANES IN USE AT HAMBURG



UNLOADING GRAIN AT HAMBURG



A SWINGING CRANE OF 30 TONS CAPACITY IN USE ON THE HAMBURG-AMERICAN LINE IN HAMBURG

dock itself free. Such a system for handling freight has been installed continuously for a distance of 18 miles. There are in all 700 traveling cranes on the docks alone. Directly back of these electric railways stand enormous storehouses, veritable skyscrapers in themselves, which make

it possible for the cargoes of the world to be unloaded and stored with the least possible effort. The trucking is carried on swiftly and silently by electric power.

The handling of grain has been reduced to a science. The grain elevators, built entirely of metal and

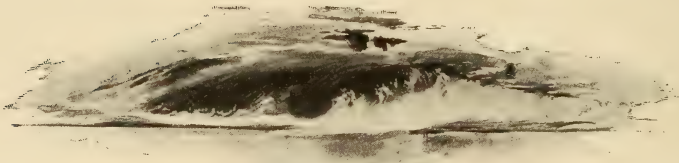
operated by electricity, are marvels of efficiency. Largely as a result of this labour-saving machinery, the grain freight service across the ocean is doubtless the cheapest in the world. The average rate for transporting grain across the Atlantic from New York to Hamburg is \$1.62 per long ton. Since 40 bushels of corn and $37\frac{1}{2}$ bushels of wheat are equivalent to a ton, the cost of transportation is really about 4 cents a bushel.

The old prejudice against labour-saving devices has been completely dissipated by the example of Hamburg. It has been demonstrated that the installation of every form of mechanical labour device has served to create employment for many thousands of workers. By keeping down the cost of production, the volume of traffic and the general activity have been correspondingly increased. So complete is the organization that prosperity has become continuously assured.

As all roads once led to Rome, so the great lines of commerce may be said to converge to-day at Hamburg. Radiating from this harbour, sixty-

seven regular steamship services travel to and fro to all parts of the world. The Hamburg-American Line calls at 350 world ports. Here is said to be the modern Tower of Babel, since the captains of the ships speak all the tongues of the civilized world. Beginning with two small ships, this service now includes 400 vessels, with a total tonnage of more than a million.

In its searches for all the newest and most efficient machinery, Hamburg has become the best market in the world for the inventor and constructive engineers. No other interest bids so keenly for the newest invention. The controlling hand in this world-wide enterprise, Herr Albert Ballin, probably owes his success to a unique genius for combining skill in finance and in engineering. There is the discipline of the army in the enormous force—there are 23,000 employees recruited under the house flag. This army is officered by men, experts in their calling, who have reached their position as a result of the most thorough training.



THE PROBLEM OF THE MOTOR TRUCK

By H. H. Suplee

WITH the development of mechanically-propelled vehicles and the enormous success of the automobile industry, it is to be expected that the employment of the gasoline motor to replace the horse in the hauling of merchandise would follow. Like many other industries which have followed upon the success of predecessors, however, the manufacture of the motor truck is passing through a course of evolution in which only the fittest can survive.

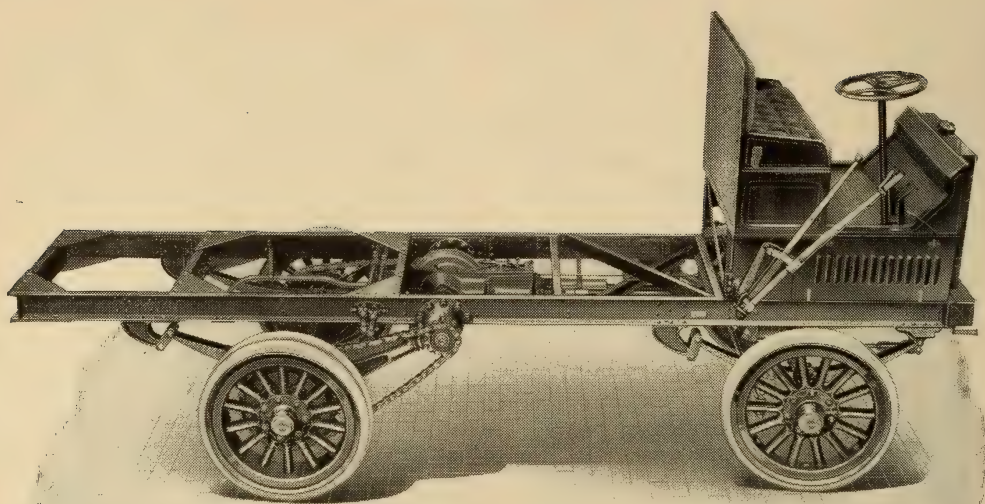
The early railway cars were close imitations of the stage coaches which they replaced, and to-day, upon railway carriages in various European countries, the lines of mouldings and the stripping of the paint may be seen to follow the curves of the old stage-coach bodies which once formed the compartments of the car. In like manner, the first attempts at automobile design were fairly close copies of horse-drawn carriages, with high wheels, leather dashboards, and other details of which the purpose had departed with the horse. It was only after designers and engineers had reached a point where they abandoned all ideas inherited from the past vehicles that the modern automobile was produced and became the successful machine of a type properly adapted to the demands of the service.

When it was realized that the motor vehicle could be employed to advantage for commercial purposes, the same course of evolution followed, and, although the precedents of the automobile had scarcely had time to become so deeply established as some of the earlier elements, yet the ideas

of the men who had designed successful pleasure cars became curiously mingled with the rooted growths of the old-time builders of horse-drawn trucks, and, to some extent, these overshadowed the fundamental elements of the problem with which the successful builder had to deal.

One of the points which the engineer finds necessary to impress upon the young pupil in the design of a machine tool is the importance of beginning right. Instead of thinking about the general appearance of the machine which he is trying to build, and the gears, pulleys, framework, etc., he is instructed to consider, first of all, the actual work which the proposed machine is to perform, and to draw the tool upon the work in its proper position, and then add the immediate parts which cause the required movements, and so build up the essentials and gradually develop the entire apparatus. This does not mean that all precedents are to be ignored, but it does mean that nothing is to be adopted simply because it has been used before, but that the whole design is to be developed on its merits, and having in view at all times the ultimate object to be effected.

Now, in the case of the commercial motor vehicle many of these fundamental principles were not wholly applied. For light delivery wagons, and for other similar purposes, it was easy to take a chassis already known to be serviceable and put a wagon body on it. Even for such a vehicle as a motor 'bus some of the first machines showed themselves to be little more than an omnibus body upon the running gear of a large touring car. The early stages of the



CHASSIS OF THE ALCO MOTOR TRUCK, 24-HORSE-POWER, AMERICAN LOCOMOTIVE COMPANY, NEW YORK

evolution simply followed the same general lines which had obtained in the growth of the automobile itself, and these things had to be outgrown, as before.

Apart from the ideas of the builder of the pleasure car, the prejudices of the maker of the horse-drawn truck entered into the question, and some rather curious combinations of existing wagons with gasoline engines were seen and advocated. The whole thought seemed to be along existing lines and their possible combinations, while the actual work to be done was scarcely considered.

There is every evidence, however, that this period of incubation is passing, and that the best modern motor trucks represent the work of men who have undertaken the solution of the problem upon correct and fundamental principles.

In the first place, it should be understood that the motor truck must be designed to cope with emergencies. Any attempt to proportion the parts or decide the powering with regard only to the actual demands of reasonable service will be certain to prove inadequate to meet the unexpected requirements which are sure

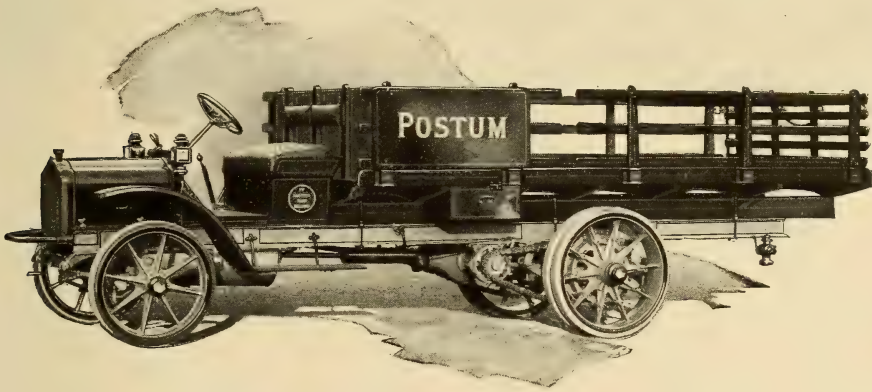
to happen. Tests made upon fair pavements with properly adjusted loads, handled at correct speeds by careful drivers, cannot be relied upon to obtain data for future use. It is when the overloaded machine gets one wheel in a hole on a slippery day and is at the mercies of an ignorant and tactless driver, with a trail of blockaded cars behind it and an insistent traffic policeman in front of it, that the judgment and ability of the man who designed the machine appear. This is the situation with which the horse-drawn team has to deal almost daily, and the machine which is to supplant the horse must do even better, or be found lacking.

The question of load capacity is one about which no uncertainty should exist. When the engineer designs a structure he endeavours to proportion the various members so as to correspond with the distribution of stresses; but, after all is done, he multiplies by a so-called factor of safety, which has been called a "factor of ignorance," and which is really a factor of uncertainty. A machine may be built to carry 5 tons, or 7 tons, or 10 tons; but in actual service it will frequently be required to carry

all that can be got upon it. The limitations which the maker may put upon his product will meet with scant observance from the crowded teamster, anxious to get his burden delivered, and working under the pressure of some chief or superintendent who looks for results and not for excuses. The truck must carry all that can be loaded on it, or be put in the same category as the balky team which it has been made to replace.

double the capacity, and unless the machine can do at least this well it cannot be said to be justifying its existence. Power is, therefore, necessary to enable good speeds to be attained, as well as to overcome obstacles.

In a well-designed motor truck the question of speed changes is most important, since the gasoline motor has its proper speed at which it works to best advantage; and when



A WHITE MOTOR TRUCK. THE WHITE COMPANY, CLEVELAND, OHIO

So far as the matter of powering is concerned, existing precedents count for little. The old-fashioned horse-car managed to get along drawn by the efforts of two horses; but anyone who would attempt to put as little as a two horse-power motor even upon a motor-cycle would be inviting failure, while the large and swift electric street cars of to-day carry motors of more than 100 horse-power. It is one thing to pull a vehicle along by pushing against the solidly resistant ground by means of direct attachment to the body of the wagon and altogether a different undertaking to propel it by turning two of its wheels. Increased speed means increased power consumption, and one of the very things which the motor truck is expected to provide is a material saving in time and manipulation. Modern motor trucks are regularly doing the work of twice as many horse-drawn vehicles of

a powerful effort is demanded to get the machine out of trouble or to start a heavy load the increased leverage provided by a very low first gear is essential.

The question of emergency requirements extends also to the materials of which a motor truck is built. Unexpected stresses demand large margins of strength, while heavy loads require liberal wearing surfaces, properly lubricated. It is well known that many materials and proportions which are all right for regular service give way under sudden shock or heavy stress briefly applied. With ample power in the motor, low gear in the transmission, and stubborn resistance at the wheel, the material of which the intermediate parts are composed decides what shall give. If the truck is to rise steadily out of the hole, or climb resistlessly over the obstacle, it is because the strength of the entire machine is



AN ALCO THREE-TON TRUCK WITH LOAD OF SINGER SEWING MACHINES

greater than the force which the motor is passing through to the obstacle. It is to meet such demands that the modern alloy steels have shown their usefulness; and chrome steel, chrome-nickel steel, or vanadium steel, selected according to the nature of the stress and given such heat treatment as to bring out the strength, toughness or rigidity desired, all have been drawn upon in modern motor-truck design.

Especially is the matter of wear important. The pleasure automobile has its styles and fashions, and, while the best cars have been designed for good endurance, it is well known that owners are not averse to changes to suit the march of the season. The motor truck, however, must meet its predecessor, the horse-drawn vehicle, and possess endurance and long life. Apart from correct proportioning in the original design, this means that accessibility, both for adjustment and for replacement, is essential for the working parts. The same rule here applies as has been found so important in the case of locomotive repairs; it is the time during which the machine is out of

service which is the most costly feature, and the cheapest repairs are those which return the vehicle to its earning usefulness with the least loss of time.

Assuming that effective, powerful and satisfactory motor trucks are now being made—trucks which will serve the requirements, not only of retail merchants, but also of wholesale establishments, manufacturers, machine works and shippers generally—let us examine for a moment what the result of the installation of such machines generally will mean to the commercial world, especially in the great cities and manufacturing centres.

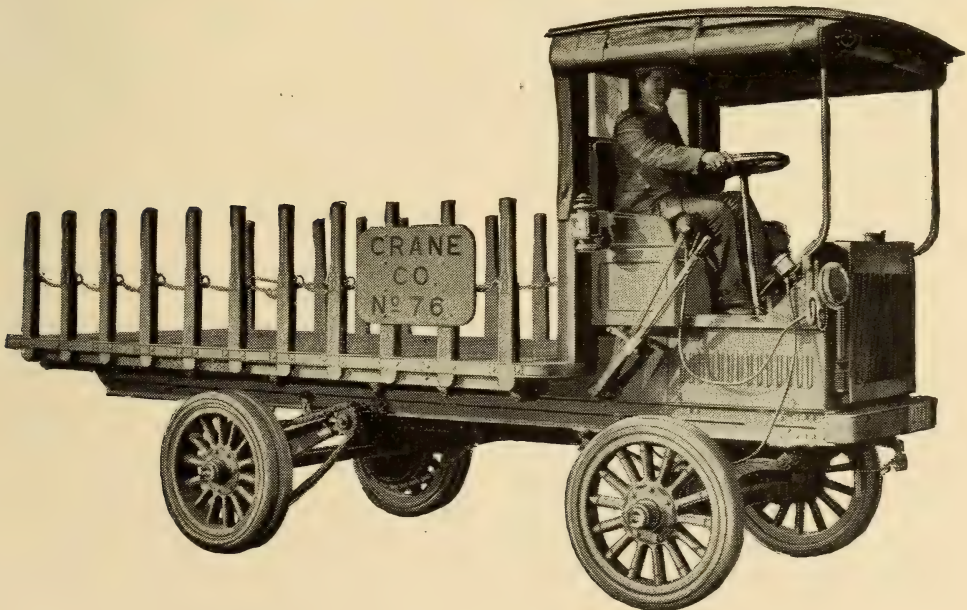
It is beginning to be understood that the weak point in the transportation systems of the country lies at the ends. The railroads are all right for long-distance transport over wide stretches of country, but they fall down most lamentably at their terminals. Indeed, the word "terminal" is an anachronism in these days of continuity of manufacturing operations, implying, as it does, that the movement of material should come to a stop at least twice in what

should otherwise be a continuous flow through the operations between beginning and ending. There is no reason why any marked terminus should occur in the handling of merchandise, and, when such does happen, it should be accepted at once as a confession of incompetence on the part of those who have assumed to take control of the movement of things.

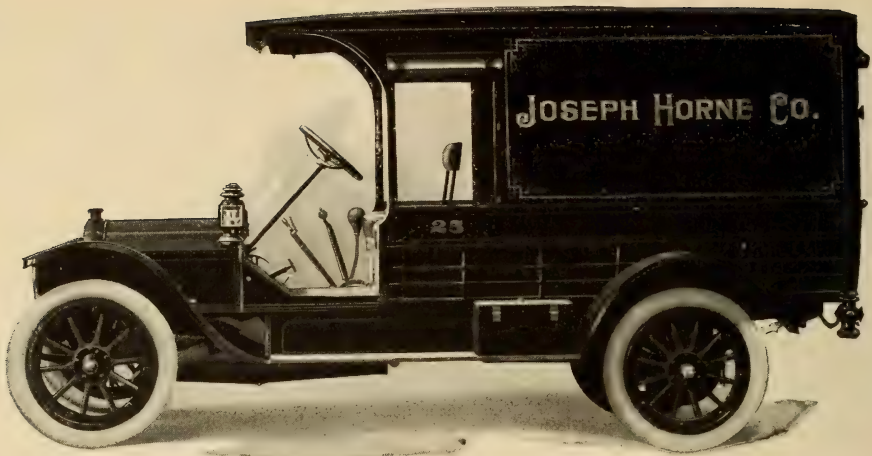
Apart from the function of the motor truck in completing the inadequate transportation facilities afforded by the railways, it will be found that much of the suburban transport, at present provided by express companies in an extravagant fashion, or not at all by the post office, as in other civilized lands, will be effected by commercial motor vehicles owned and operated by the merchants themselves. Residences within a radius of many miles around the great commercial centres will be supplied from the large depots of household supplies over the main highways, independently of the transport opportunities grudgingly afforded by public and semi-public methods. Probably one of the most

important functions provided by the mechanically-propelled vehicle will be the independence with which the ever-increasing suburban population about our great cities will be rendered independent of the limitations of local establishments for their household supplies.

Aside from the independence of local supplies which will thus follow the general introduction of the motor truck for delivery purposes, it may be worth while to call attention to some of the desirable results which will follow the elimination of the horse from our municipal and domestic economy. Domesticated animals have been with humanity for so long a period that they seem to have acquired a sort of vested right; but when the disadvantages which accompany their use are weighed against the advantages of mechanical appliances, it will be seen that the preponderance is wholly on the side of the machine. The manner in which the domestic fly acts as a spreader of disease is now fully accepted and understood, but it is not so fully understood that the principal



THE ALCO MOTOR TRUCK FOR MANUFACTURING SERVICE



WHITE MOTOR DELIVERY WAGON, 1,500 POUNDS. THE WHITE COMPANY, CLEVELAND, OHIO

breeding places of the disease-carrying fly are due to the presence of the horse in proximity to human dwelling places. For this reason, if for no other, the horse stable should be banished from the city and relegated to places where the accompanying vermin can do no harm to crowded humanity.

The question of the cleanliness of the streets is also to be considered. It is well understood that a large proportion of the dust which renders city streets so objectionable is due to the presence of the horse, and, while it is true that there is objection to be raised to leakages and drip of gasoline, this latter could be wholly avoided by the use of proper drip-pans upon the motor vehicles.

It should be understood and accepted upon the part of the public that the motor vehicle has come to stay, as well for commercial purposes as it has for personal transport. This being the case, it remains only to see that the requirements for commercial vehicles are met by their constructors and that the full advantages included in their possibilities are realized.

In this connection it should be remembered that the construction of

city pavements is closely related to the kind of vehicles of which the traffic is composed. The use of the horse includes a pavement upon which his hoofs may obtain a hold and over which horse-drawn vehicles may be hauled to the best advantage. The motor vehicle acts in an entirely different manner and demands a different kind of surface. In both cases it must be remembered that a pavement is composed of much more than a mere surfacing, and that a proper foundation, well drained, solidly built and smoothly finished is absolutely necessary to carry any kind of surfacing, whether of asphalt, wooden blocks, or cut stones. It is probable that properly cut stone, hard, smooth and very closely jointed, will prove the best for commercial motor vehicles; but such a pavement means something far different from the ordinary granite block, with rounded edges, wide cracks, and shifting sand foundation. Proper delivery facilities in the modern cities means mechanically-propelled vehicles, designed especially for their service, and operating upon really honest, smoothly-surfaced pavements, laid upon deep, smooth and solid masonry foundations.

A COMMUNITY OF INTERESTS

A BIT OF ENGINEERING HISTORY

By W. L. Saunders

It is always desirable that the facts in connection with the development of the applied science of engineering should be placed on record, and it is especially important that such historical records should be made by those who are entirely conversant with the facts. Under such circumstances, the following account, from the pen of the president of the Ingersoll-Rand Company, is of much interest, showing, as it does, how two mechanical problems, having points both of similarity and wide difference, were solved many years ago in such a fundamental manner as to have survived and progressed to continually increasing influence.—THE EDITOR.

THE recent change in the proprietorship of the Cameron Steam Pump Works from the widow of the inventor to the Ingersoll-Rand Company has excited a good deal of attention and some misunderstanding. As a matter of fact, the Ingersoll rock drill and the Cameron pump have always been very closely associated, each being about the same age—namely, forty years. It was in a little shop on the corner of Second avenue and Twenty-second street, New York, that both the Ingersoll drill and the Cameron pump originated, and for some years the manufacture of both took place under the same roof. The late Henry C. Sergeant, who is admitted to have done more in the invention and development of the rock drill than any other person, designed the first really successful Ingersoll drill, getting his fundamental ideas of the valve motion from Mr. A. S. Cameron. This was at a time when even the fly-wheel engine was more or less of a novelty, and a reciprocating engine, like a pump or rock drill, with no crankshaft to carry it around the centre, was practically unknown. The first machines of this class were built on steam-engine lines, the valve itself being mechanically connected with the piston. In the first Ingersoll drill, as in the first pump, when the piston reached the end of the stroke it reversed the valve by direct mechanical contact with knuckle joints, rods or other devices, which intervened between the piston and the valve.

Here is where great credit is due to Mr. A. S. Cameron. He was seeking to perfect a pump which should be used in rough places where exposed parts were liable to wear and injury. He also wanted to build a valve which would open up a large port at the end of the stroke at the instant that the piston reached a certain point. This was hardly practicable with a mechanically-moved valve without excessive shock and wear. Cameron's invention, therefore, was to place a small tappet or knuckle in each cylinder head of the pump, which would serve as a trigger to be tripped through contact with the piston and open a small port connecting either end of the valve. The valve itself was submerged in live-steam pressure, equal on both ends; hence, when this tripping action took place it reduced the pressure on one end, so that the active pressure on the other caused it to reverse. In order to do this with the minimum shock at the tappet, or with a small trigger action, and also taking into consideration the importance of having a small port controlled by such action, Mr. Cameron used a plunger piston, which, in turn, overlapped the valve itself, this plunger piston having an area on each end which might be greater or smaller, according to the resistance of the valve to the action of sliding on its seat. The valve itself was, and still is, a slide valve, which, as everybody knows, rests tightly upon its ports and does not leak by wear.

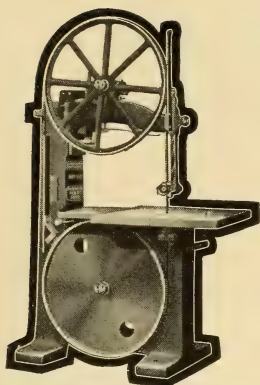
Sergeant had a problem more difficult than Cameron, because, in the first place, the speed of a pump is only about 100 feet per minute, while that of a rock drill is four times as great. This high speed made it difficult to use any kind of a tappet trigger, and, in order to get the quickest action of the valve (Sergeant sought to obtain the slide valve) and to use the plunger or valve-moving device of Cameron as the valve itself. In doing this he ran against another difficulty. The valve, in order to be tight on its seat, would press so hard that the speed of the drill became sluggish. To overcome this he ran a bolt through the center of this valve, which relieved it of a certain portion of this pressure. Instead of the tappet trigger, Sergeant moved his valve by causing the piston of the drill to uncover passages leading to each valve end. Here we have the identical principle, so far as the valve movement is concerned, that is embodied in the Cameron pump—namely, an equal pressure on both ends of the valve and the valve moving through a disturbance of that pressure on one end and the other alternately, the action itself being controlled by the strokes of the piston. No better evidence is needed of the success of this valve action than the fact that the Ingersoll "Eclipse" drill and the Cameron pump are at work to-day with valves of this construction.

The community of interests between Cameron and Ingersoll has extended from this inception to the present day. The castings for the first air compressors of the Ingersoll make were made in the Cameron foundry, on East Twenty-second street. For many years, and until the Ingersoll works were moved to Easton, Pa., the castings were made by Cameron. The success of the Cameron pump in mines, quarries and for contractors' service brought it close to the Ingersoll business. In

South Africa and other places the Ingersoll-Rand agents have been the agents for the Cameron pump.

Adam Scott Cameron was the youngest of four brothers, all of whom took up mechanical pursuits. While a youth, in serving his apprenticeship, he was a student at Cooper Institute, giving his nights and spare time to study and research. He graduated with honors, and at once applied himself to mechanical matters. He was engaged in building the Sewell and Cameron crank and fly-wheel pump, which during the Civil War was in demand by the United States Navy and the merchant marine. At the close of the war the call for these pumps fell off, so that Mr. Cameron turned his attention to the design of a pump of greater adaptability and more general application. The standard Cameron pump was the result, its acorn-shaped air chamber, the emblem of the clan Cameron—the oak—being his trade-mark, and continuing up to the present time. He died at an early age, but before death he stamped his ability and force of character upon the mechanical engineering of his age. His widow carried on the business up to a recent date, the management being for the past eleven years in charge of Mr. George Ward Fuller, to whom much credit is due for the successful introduction of the Cameron pump throughout the world. Mr. Fuller is a New Yorker, of Scotch-Irish parentage. He left school when quite young, entered the employ of the Tapscott Packet Line of sailing vessels, afterwards going with the Westcott Express Company and with B. Altman & Co. He continues as vice-president and general manager of the Ingersoll-Rand Company, Mr. George Doubleday, who is first vice-president of the Ingersoll-Rand Company, being president, and the directorate being composed of Mr. Fuller and the directors of the Ingersoll-Rand Company.

NOTES



A PATTERN SHOP BAND-SAW. J. A. FAY & EGAN CO.

A Pattern Shop Band-Saw

THE band-saw shown in the illustration is manufactured by J. A. Fay & Egan Company, 226-246 West Front street, Cincinnati, Ohio. The fact that the manufacturers designed their No. 50 band scroll saw for use in shops having a considerable amount of plain or intricate scroll sawing to do, makes it especially adapted to the pattern shop, where this kind of work is turned out daily.

For pattern shop work the manufacturers arrange the table with a tilting device having micrometer adjustment, which enables the operator to instantly adjust the table to any angle up to 45 degrees to the right and 10 degrees to the left. This device is said to combine quick and accurate angling of the table, which will be found of great importance to the pattern maker.

The most important feature in the construction of this machine is the straining device, which is known as their patent knife-edge balance. The upper wheel is hung solely on a knife-edge, and the tension on the blade is given by a compound lever arrangement. This is a most perfect device for straining the blade. Its action under all conditions is instantaneous; it enables the machine to run at a high rate, with absolutely no danger of breaking the blade, no matter how fine it is.

Many other features which have contributed to its favor among pattern shops are fully described in the manufacturers' large illustrated circular, for which you are invited to write.

Sure-Footed Sanitation

BY C. H. OAKLEY

FEW of the thousands who compose the continually moving mass of humanity which frequents our streets, shops, stations, places of amusement and office buildings appreciate the study and physical effort which are constantly being put forth to make possible the safe and convenient accomplishment of our daily activities.

Formerly a hotel was supposed to have fully discharged its obligations by affording a place to sleep and to eat; a railway station merely provided an opportunity for the purchase of transportation and the checking of baggage. Office buildings were usually unwholesome affairs, illy arranged and lacking in both light and cleanliness. These and many similar conditions, however, are now things of the past, and we find our purveyors of public utilities, such as the administrators of hotels, office buildings, theatres and railroad terminals, vying with each other as to which shall be the first to introduce some added convenience, element of safety or attractive environment to make possible the quicker, safer and more pleasurable culmination of our daily efforts toward equalizing the world's wealth, knowledge and comfort.

These tendencies toward the conservation of our physical well-being, comfort and safety enable us to keep pace with the ever-increasing competition of the times, rendering possible the performance of more things each day with the exertion of less physical and mental effort than would have been possible twenty years ago.

(Continued on page 58.)



FINANCIAL NOTES OF THE INDUSTRIAL WORLD

Rapid Growth of the Electric Industry

WHILE the birth of the use of the electric current as a means of light and power is not so far back but what the man of middle age easily recalls it and remembers well his first sight of the arc light, its wonderful development and growth have been such that it is hard for one to realize that only a few years ago such use was a novelty and not a necessity, as at present.

The statistics compiled by the Bureau of the Census, and recently published, reveal how remarkable its growth has been during six years in the United States.

In 1902 the number of incandescent lights in use was 19,636,729; in 1907, six years later, we find the number has increased to 45,991,336; while the increase in arc lights during the same period has been 220,254, the former lamps having largely superseded the latter for the lighting of streets.

An indication of the vast capital invested in the electrical industry is also forcibly given in the same report, which shows that the cost and equipment of central power stations throughout the United States has doubled in six years, in 1907 the cost being \$1,096,913,622. During this same interval the horse-power capacity has more than doubled—i. e., 4,032,365, as against 1,830,594, while in 1902 the output of the stations was 2,507,051,115 kilowatt-hours; in 1907, 5,862,276,737.

Probably the increase in the use of the electric current for such purposes during these six years, was greater than the pioneers in the field of electric light and power expected the to-

tal use of the newly harnessed energy would reach in their lifetime.

The Marion Shovel & Dredge Company Erecting Four New Shop Buildings

Ground has been broken for the new plant of the Marion Shovel & Dredge Company, Marion, Ohio, and it is expected to have it ready for operation in February. Four shop buildings, a machine shop and erecting room, 120 x 210 feet; blacksmith and structural shop, 60 x 210 feet; carpenter shop, 60 x 112 feet, and a power house, 60 x 100 feet, are to be built. The general manager and secretary of the company is Mr. A. E. Cheney.

Manufacturer for Special Machine Wanted

To the manufacturer desiring to add a new product an unusual opportunity is offered for the manufacture of a machine on an extensive scale. Those desiring information can obtain same by addressing M. P. M., care of CASSIER'S MAGAZINE.

The Clark Power Wagon Company, of Lansing, Mich., have recently increased their capital stock.

With a capital stock of \$200,000, the Clark Engine & Boiler Company, of Kalamazoo, Mich., has been incorporated.

In the first week of October permits were issued for the erection of new buildings in Toronto of an aggregate value of \$340,000.

FINANCIAL NOTES

Development of New Processes

Of great value to the manager of chemical and miscellaneous manufacturing plants is the service now being rendered by The Griscom-Spencer Company, 90 West Street, New York. This firm, which operates its own shops and maintains a large general supply business, being designers, constructors and salesmen of economical and efficient plant equipment of every kind, will always be found ready to co-operate fully in the development of new processes, designing such special apparatus as may be necessary and particularly in adapting standard market goods to special purposes at a large saving in their cost.

This is a service which without doubt manufacturers will greatly appreciate.

A Manufacturing Plant For Sale

There is now in the market a fully equipped manufacturing plant which is ready to be started with no practical delay.

This plant has been used for the production of alternating electric generators, steam turbines and other engineering apparatus, and due to its location has exceptional facilities which include five railway systems and lake transportation, and in addition a cash bonus can be secured for a desirable enterprise. The opportunity is one which should be of interest to either a new enterprise or to the established company seeking a location for a branch plant. Full particulars can be obtained by addressing H. C. H., care of CASSIER'S MAGAZINE.

National Aero Show, St. Louis

The management of the St. Louis National Aero Show, which opens in the Mammoth Coliseum Building Nov. 17 and continues to the 24th, report that they have secured many most interesting exhibits, and that present indications are that the show will be

very largely attended. Mr. G. L. Holton is the manager of the enterprise, and should be addressed for all information.

The Location of an Industrial Plant

Given everything else equal there is no doubt but what an industrial plant which by its location possesses the most convenient, favorable and economical facilities for the receipt of its raw material and the wide distribution of its finished product will be the most certain to find the balance at the end of the year on the right side of its ledger.

The manufacturing concern seeking a location either for a new plant or for the establishment of a branch plant, will find it worth while to correspond with Mr. Ira H. Shoemaker, Albany, N. Y., Industrial Agent of the Delaware & Hudson Company, which road not only parallels the upper Hudson, but provides a fast freight service to the East, North and South, as well as to the new 2,000-ton barge canal now being built by the State to connect the river with Lake Champlain, thus offering an establishment located in its territory unequaled shipping facilities and the benefit of cheap fuel, electric power and low freight rates.

The eleventh gas plant designed by Mr. Henry I. Lea, the well-known consulting gas engineer, of Chicago, was not long ago placed in commission, and is now in successful operation. The plant supplies the cities of Ironwood, Mich., and Hurley, Wis., which have a combined population of about 19,000.

Professor A. N. Talbot, of the College of Engineering of the University of Illinois, is serving as a member of an expert commission which is engaged in inspecting and reviewing the work of construction of the new City Hall of Chicago.



THE LATEST CATALOGUES

Rock Drills

The Ingersoll-Rand Company, of New York, have just issued a very complete description of the "Sergeant" drill, fully illustrated.

Monthly Stock List of Machinery Bargains

In the Monthly List of Machinery Bargains, which is issued by Wickes Brothers, of Saginaw, Mich., there is given each month a large selection of boilers, engines, pumps, machine tools, electrical machinery, etc., which is of decided interest. This firm claims for its refitted machinery a value as good as new, at a saving of from one-third to two-thirds in price.

Mail Wrapper Tube

From the Hi-Lo Desk Company, 154 Nassau street, New York, comes descriptive matter of their new mailing tube, an exceedingly useful device for mailing plans, blue prints, etc., which assures absolute safety in the mail. Descriptive matter and sample tube can be obtained on request.

Conveyor Belts

John J. Ridgway, P. O. Box 1,855, New York, will be glad to send those who may be interested a little book entitled "How To Buy Conveyor Belts." The work takes up three primary things to be considered in a conveyor belt: fabric, the bone and muscle, friction, the heart and soul, cover or pad, the stamina or endurance, and is full of information. Copies can be obtained by addressing him.

Belting

Albeco Laminated & Leather Belt Company. Under the title of "The Difference Between Albeco

Laminated and Multi-Lap Leather Belting," the American Laminated Belting Company, 111 Hudson street, New York, have issued a booklet which is especially interesting in that it gives close comparisons of the operating principles, power-transmitting qualities and ultimate economy of both types of belting.

That laminated belting can handle heavy loads is forcibly shown in this booklet by the description of the main drive in the Cocheco department, Pacific Mills, Dover, N. H., where 84 inches width of laminated belt on one pulley are transmitting 1,544 horse-power. These belts, consisting of two 30-inch and one 24-inch belt, all $\frac{5}{8}$ inch thick, are said to comprise the largest installations of laminated belting on one drive in the world, and were installed by Lockwood, Greene & Co., the Boston mill engineers, because no lapped belts would transmit the power under the severe conditions imposed.

The book is fully illustrated, and is well worth the attention of power users. A copy may be obtained by addressing the company issuing it.

Steam Engines

Bulletin S-77, issued by the Providence Engineering Works, Providence, R. I., relates to Rice H. Sargent Corliss engine steam consumptions and friction losses, and should interest all who are connected with the use of steam power. The tests to determine the results described in the pamphlet were made by such well-known engineers as Prof. D. S. Jacobus, Geo. E. Barrus, etc., who in all cases represented the purchasers of the engine. A letter addressed to Mr. Elmer Smith, assistant secretary of the above-mentioned works, will bring a copy of the bulletin.

LATEST CATALOGUES

Modern Street Lighting

The General Electric Co., of Schenectady, N. Y., have recently issued an attractive booklet entitled "Modern Street Lighting by Luminous Arc Lamps." The work is devoted to the subject of street lighting by the General Electric series luminous arc rectifier system, and contains illustrations of the vertical carbon flame arc lamp, with brief description. Mention is made of the station equipment required by the system, and there is also given a list of the cities where installations of it have been made. By addressing them and mentioning publication B—3,014, a copy may be obtained.

Hammer Drills

From the Sullivan Machinery Company, 150 Michigan avenue, Chicago, Ill., is received their Bulletin No. 60—D, describing the new Sullivan stoping drill. They claim for this drill that it is the fastest, most durable and efficient hammer drill made for drilling upper holes, and that it is easy to operate and care for and simple in construction.

The Mechanigraph

Topping Brothers, 122 Chambers street, New York, have just issued an exceedingly handsome work on the Mechanigraph, a machine which, in an instant, makes transparent and printable an opaque pencil or pen drawing at a cost of approximately a third of a cent per square yard. In fact, the book treats of a new way of doing things and is well worth owning.

Regulators, Regulating Valves, Etc.

Leaflets are received from the Ziermore Regulator Company, Johnsonberg, Pa., giving descriptions and illustrations of Ziermore regulators and regulating valves, as follows: Style A, pressure controlling valve for the control of volatile pressures; Style B, stoker and forced draft regulator;

Style C, flexible steam throttling valve; Style D, boiler feed pump regulator; Style E, low-pressure regulator, double adjusting; Style F, water level regulator for steam boilers; Style G, fuel, gas and oil regulator for steam boilers; Style H, vacuum pump regulator; Style K, regulators for elevators, fire pumps and paper mill digesters. Copies can be obtained by addressing the company.

Single-Phase Induction Watthour Meters

There has recently come to hand from the Fort Wayne Electric Works, of Fort Wayne, Ind., their Instruction Book No. 3,043, which gives very full and easily understood instructions concerning their Watthour meters and their use. Considerable additional matter of interest is also given. Other catalogues received from this same firm take up their "Northern" Type B direct current generators, their portable Watthour meter, calibrators, etc.

Chloride Accumulators, Tudor Accumulators, Exide Batteries

A new series of bulletins regarding their products and containing illustrations and text descriptive of their actual installation and use has been issued by the Electric Storage Battery Company, of Philadelphia, Pa.

We would acknowledge the receipt also of catalogues and other publications from the following firms, which are held for future notice:

Industrial Instrument Company, Foxboro, Mass.

De Laval Steam Turbine Company, New York, N. Y.

International Harvester Company, Chicago, Ill.

General Electric Company, Schenectady, N. Y.

Cutler-Hammer Clutch Company, Milwaukee, Wis.

Electric Locomotives

THE problem of handling material within the shop has been met by a number of ingenious and effective devices, including all kinds of cranes and hoists, by industrial railways, and by combinations of chain blocks and overhead tram-rail. Such devices, however, necessarily have their limitations. The overhead traveling crane, whether operated by hand or by electric power, can carry its burden no further than is permitted by its runway, which usually confines its operation to the single building in which it was originally erected. In some cases such runways have been extended upon strong trestle-work, so as to cover portions of storage and loading yards; but, in general, the traveling crane is used to the best advantage within the limits for which it was especially designed. In like manner the overhead tramrail, which has so successfully extended the scope of the chain block, is limited in its uses. It can be carried around curves, and, by the use of switches and turnouts, it can be made to serve over a far wider range of work than is possible to its larger and more powerful neighbour; but it also is most efficient when judiciously employed for single pieces of work, conveyed between definite points and for definite purposes.

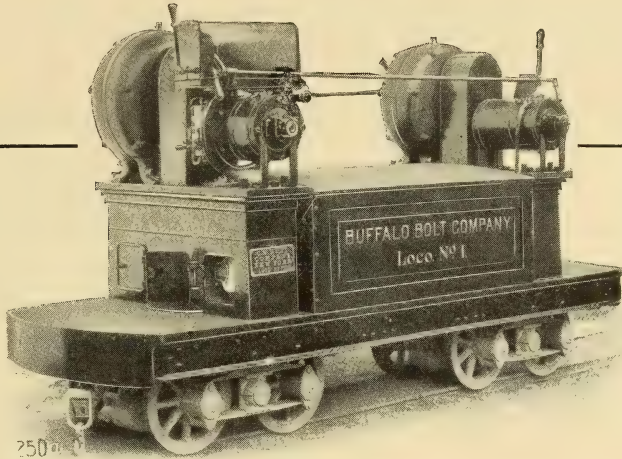
The industrial railway fills a somewhat different sphere of work, whether in the shop or out of it. The cars may carry a single piece, or may be loaded with rough castings, finished parts, or work in progress of machining and in course of transit through the works. It can be used to act as a feeder to the electric-power traveling crane or to the overhead tramrail and chain block, and thus work together with both to form a complete system of transport, saving labour and economizing time in a manner certain to have an important influence upon the reduction of manufacturing costs.

It has been well said that manufacturing establishments are rarely

planned out beforehand, but that they grow, usually along the lines of least resistance. These controlling influences are often such as to require separate buildings, not always situated most advantageously to each other, so far as the ordinary handling of material and work is concerned, and it becomes necessary to provide for such growth, not only in its early stages, but with some system of sufficient elasticity to permit future extension without serious disturbance to the earlier portions. It is in just such cases that the industrial railway finds most successful applications, rendering possible communication and transport between all parts of an establishment.

With this development of the industrial railway has come the provision of a most effective motive power in the form of the electric storage battery locomotive. Such a locomotive, designed upon the line of the rest of the industrial railway equipment, is able to haul any desired load up grades, around standard curves of 12 feet radius, to any part of the establishment to which tracks can be run. Containing its own stored power, it is independent of any external connections, thus avoiding the necessity for overhead trolley wires, local connections, or limitations. It consumes power only when in actual operation, and requires the services of but one man for its effective work. The batteries may readily be charged at times when its services are not demanded, and its presence transforms the industrial railway from a hand-operated system to a power railway, without in any way detracting from its use by manual power.

The urgent question in works administration to-day is the reduction of manufacturing costs, and especially in those costs which have been considered as not directly productive. Among such items of expense that incurred in handling material holds a prominent place, and its reduction demands the intelligent use of the best power appliances.



HUNT STORAGE BATTERY LOCOMOTIVE
21½ inches gauge

ONE of the best types of Labor Saving Machinery is the HUNT ELECTRIC STORAGE BATTERY LOCOMOTIVE.

With it one man can handle all the material in a large Manufacturing Establishment.

It runs around curves of 12 feet radius as easily as a wagon turns a corner, making readily accessible every part of the works, and easily hauls the loaded cars up the grades frequently found in establishments that have grown by successive additions.

No trolley wires are required, and there is no expense on holidays or when work is slack.

We will be pleased to correspond with those interested in reducing the expense of handling their materials.

**Hoisting and Conveying Machinery, Cable Railways,
Automatic Railways, Steam Shovels**

C. W. Hunt Co.,

**West New Brighton, N. Y.
N. Y. City Office, 45 Broadway**

Atlanta, Ga., 607 Rhodes Building
Richmond, Va., State Bank Building

Chicago, 1616 Fisher Building
San Francisco, 865 Monadnock Building

Keeping up the Pace

EVERYONE is interested in getting on; he wants to get on himself, and he soon learns that the best way of accomplishing this laudable object is to keep his work moving, and moving in the right direction.

The well-conducted manufacturing establishment is a gigantic example of the continuous flow of material through what may be termed a sort of digestion, the crude substances and materials entering and being transformed, disintegrated, reunited and perfected into the finished product, far different from the original elements, vastly more valuable, and greatly improved by the rejection of the waste and useless portions.

Such a process, to be effective, must be made as nearly continuous as practicable; the flow will have its interruptions, but these should be only such as are necessary and useful, including the reception of material, its placing in the tools and its removal therefrom, and such brief stops as are unavoidable. On the whole, however, there should be a steady progress, and the motto should be "step lively" in fact, if not in words.

Such a conception of the manufacturing establishment was long ago found practicable in connection with the production of light articles, in which the movements could be effected without the aid of special transportation appliances. When, upon rare occasions, some heavy piece had to be lifted, a special tackle was rigged, and the job was considered as an exception. By and by, when heavier parts became the rule, it was found desirable to use chain hoists to do the lifting, but the transport was effected upon trucks or other primitive appliances.

This state of affairs did not conform to the idea of continuity of movement, however; there were too many interruptions; and what with loading and unloading, and with the separation of the jobs of lifting and transporting, the handling became un-

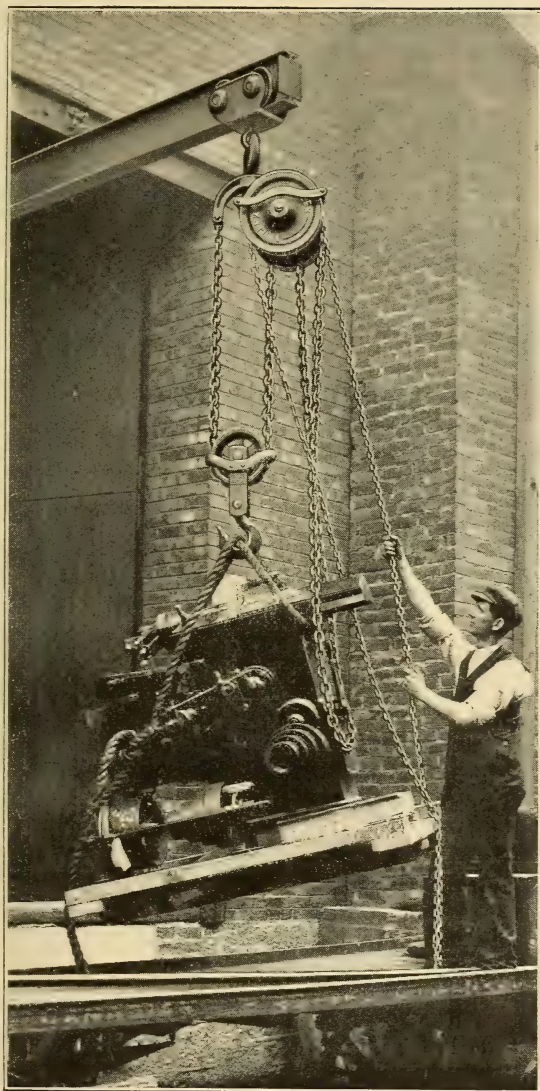
equal to the pace of the rest of the work. The loading and unloading points became congestion centres as truly as do similar points in municipal transport when the human burden is dumped and reloaded.

Then it was found that half of the work which had been so laboriously performed was wholly unnecessary, and that the right thing to do to keep up the flow and to prevent the choking was to pick up the burden and let the hoist which raised it continue to hold it until it was transported to the next point for work. The overhead tramrail added a new power to the hoist; it made it do two jobs instead of one, and it doubled its capacity. The tramrail can go anywhere, and where the tramrail goes there its burden can be delivered; the hoist not only lifts it, but holds it in the air and deposits it at its destination, whether this be the way station before or in a tool, or at the terminal upon the truck or car which carries it away.

Apart from the cost reductions thus possible, there are other points which make indirectly for efficiency and economy in the use of the combination. The rough and often encumbered floor is replaced by a clear and smooth railway overhead, and thus the actual labour of moving is made far easier. The burden is not only raised from its place to a height which permits it to clear all obstructions, but it is automatically and securely held, free from accident or injury either to itself or to the attendant, and thus sustained until it reaches the point where it is to be lowered and delivered.

Such an overhead tramrail system, properly installed and equipped, forms a most flexible and serviceable method of maintaining the flow of work through a manufacturing establishment; its capacity extends from a few hundred pounds to several tons; its reach covers the whole works, and can grow with the growth of the plant; it solves the problem in a broad and scientific fashion.

Lifting is Only Half the Job



A Triplex Block on an overhead trolley does a good deal more than lift. With it one man can then go to any part of your works, pick up any kind of material from a 200-lb. box to a 20-ton casting,—push it along the overhead trolley and set it down in any other point in the works, or on a truck or freight car for shipping.

This picture shows a length of trolley projecting out of the shipping-room door, which makes very easy loading or unloading.

One man does it all, and this method of transportation is so much easier, quieter and quicker than the old hand truck or hand car that the whole cost of the inexpensive installation is very soon paid for.

More than that, you get the absolute freedom from accident, for when a Triplex Block once gets hold of a load, it will never let go until you are ready. *You* may have one to try by asking us or your nearest dealer.

A quick and easy way of loading and unloading

Chain { 4 Styles: Differential, Duplex, Triplex, Electric.
42 Sizes: One-eighth of a ton to forty tons.
Blocks { 300 Active Stocks ready for instant call all over the U. S.
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Lessons of Experience

IN getting power from the point where it is generated to the point where it is to be utilized, there is room for the exercise of much judgment and care.

The first steam engines were built to pump water from mines. Since they were intended to be connected to vertical reciprocating pumps, they were built with vertical cylinders fitted with reciprocating pistons; and as it was not considered practicable to place them directly over the pit, the heavy parts of the engine were placed on one side and a beam used to reach out over the hole and make the connection with the pump rod, which extended down to the flooded workings. Here was a direct connection between the power and the resistance; but when, later on, it was found desirable to drive mill machinery by steam power, nothing better could at first be thought of than to take the pumping engine and chop off the upper end of the pump rod, in order to connect it to a crank. The crank was a necessity, because the mill machinery was mainly rotary in its movements and could not be worked like a pump. It took several generations to discover that the beam was unnecessary when there was no pit's edge to reach over, and it has taken several more generations to accumulate a really valuable fund of experience for use in other departments of power transmission.

To-day, however, things are beginning to be reasoned out from end to end. In many cases it is found possible to use prime movers which are themselves rotary instead of reciprocating, and in nearly all instances the power from the engine, steam turbine, hydraulic turbine or other motor is delivered to the point where it can really do some work in a scientific and efficient manner.

In some cases electric transmission is found desirable for at least a portion of the way, especially in the last stretch, connecting with a motor on

the tool. In other instances—probably, as yet, the majority of cases—nothing better has been found than a leather belt running over a pair of pulleys. In very many situations, however, the use of rope transmission meets the demands of the work better than either of the others, and the widely extending use of the rope drive is an indication of its fitness for the purpose.

Originally the use of a rope instead of a belt seemed to be a very simple matter; it was a sort of round belt, running in grooved sheaves instead of over cylindrical pulleys, a thing that anybody could rig up. When, however, it was desired to use rope driving for larger power transmissions than could be effected by a single rope, the first idea was to use two or more separate ropes side by side, assuming that they would pull together as well as they had done separately. This combination—the so-called "English" system—works well in some instances, just as the walking beam of the early mill engines worked well, although it belonged to a really different kind of work. Later experience, however, developed the "American" system, using a continuous and endless rope in the place of a number of separate ones, and thus began the scientific development of the rope drive, permitting the employment of a separate tension sheave and enabling all kinds of problems to be met and all directions to be made possible in power transmission.

With this wiping off of the slate and the making of a fresh start came the opportunity to develop a really complete system of rope transmission, and during the twenty-five years in which this development has taken place there has been accumulated a fund of experience covering almost every possible case which may occur in practice. This experience permits the installation of rope transmissions with a minimum of friction loss, of noise and of maintenance cost, and assures the attainment of maximum efficiency, durability and economy.

DODGE

The Efficiency of a Rope Drive is in the Design

Rope drives, correctly planned, are the most satisfactory form of transmission for a great many situations.

But successful, economical rope drives represent many intricacies of design—learned only through long experience.

We have been designing and furnishing rope drives for more than twenty-five years.

We know the high efficiency that can be secured from them, and we know those fine points of design necessary to secure this efficiency.

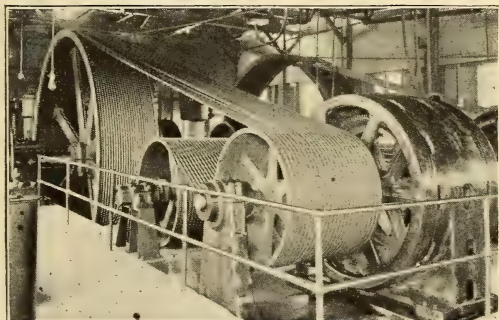
Hundreds of Dodge Rope Drives are operating in all sorts of plants, under all sorts of conditions.

Operating with minimum friction loss, noise and maintenance expense.

And demonstrating the excellence of our designs, as worked out by the corps of engineers which we maintain for the solution of power transmission problems.

If you are contemplating the installation of any transmission equipment, let our transmission specialists advise with you as to the efficiency to be gained by one of our American System Rope Drives.

We will be glad to submit plans for a Dodge Rope Drive, the profitable operation of which we can warrant.



Simply send us information and sketches, showing conditions to be met, and secure our plans for consideration.

Our Book C-76, "Twenty-five years of Rope Driving," contains valuable information on this subject. This book is 9" x 12", 104 pages, price \$1.00. However to owners, managers, superintendents, master mechanics and chief engineers of power-using plants, interested in this subject, we will be glad to send a complimentary copy.

Send the coupon or write.

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Please send me your
book, C-76, "Twenty-five
Years of Rope Driving."

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The New Tool in the Engineer's Kit

THE skill of the workman is worth but little unless he has a proper kit of tools, and the range and excellence of his work will depend upon their variety and their condition of efficiency. The tools at hand often determine the way of doing a job, and a lack of the right tool often makes a job cost too much. We are all familiar enough with the puttering of the carpenter or the plumber who comes to do some repairing about the house without the proper means for doing it.

The mining and tunneling engineer, the planner and executer of the larger works in rock excavation and stone construction, has his kit at command just the same as the workman. Although he does not lug his tools on his shoulder or personally handle them at all, still they are under his direction and must do his bidding. In the later years he has welcomed valuable additions to his kit, and these have so transformed his methods and quickened and extended his achievements as to make those of the ancients seem absurd and even contemptible in comparison.

Prominent in the modern engineer's kit are rock drills and the high explosives. These have vastly cheapened his work, enabling him to accomplish so much and to do things so rapidly that he might be expected soon to be looking for other employment; yet, in accord with the general habit of progress, the work is piling up ahead of him faster than ever, and he is hustling to improve his facilities, especially by concentration and simplification at the power end.

The problem of the drive for the widely distributed machinery employed in mining, in tunneling, and in the larger operations having to do with water transmission and improved facilities for navigation is most urgent. Steam had it all its own way for a long time, and claimed, after a fashion, to drive

everything. Then came the rock drill, insisting that only compressed air was good enough for it, and later we have electricity, the most boastful and self-sufficient of all. Electricity has failed to make good, so far as the direct driving of rock drills is concerned, and now, mostly in consequence of that, we have extensive operations in progress where steam, compressed air and electricity each have their own peculiar share of the work, while the desirability of one driver for all is apparent.

How much better would be the one general means of power transmission than the three, especially when there can in these days be but little question as to what, in many cases, it should be. Electricity we must have, anyway, for our lighting, and for all machinery which is essentially rotative it does its work with little loss at either end, or even along the way, if it be not excessively long. Where, as often now happens, there are special reasons for the use of electricity as the means of power transmission, it can do practically everything except to drive the rock drills.

This disability prevails no longer, having been immediately annihilated by the advent of the electric air drill. While this drill is an air-operated machine as completely and entirely as any machine ever designed, it is just as completely, right up to the apparatus itself, an electric-driven machine, and it has no source of power other than the wires which connect it to the generator.

The most remote and diverse conditions suggest the special adaptability of the electric air drill. It can be placed and operated at its best in locations inaccessible to any other drill. Some of our most valuable mineral deposits are in the most out-of-the-way places, but the drill may be transported wherever men can climb, and a wire is all that is required to actuate it. In excavating for building foundations in our cities nothing could be so handy, as current is always on tap.

INGERSOLL-RAND CO.

NEW YORK LONDON



"ELECTRIC-AIR" ROCK DRILLS

At high altitudes the economy of the air compressor falls off, due to the rarification of the intake air.

Power, too, is likely to be a costly item because of the inaccessibility, adding to cost of fuel: and the transportation of heavy power plant machinery becomes a difficult problem.

The "Electric-Air" Drill finds its most attractive field under these conditions. If a transmission circuit is not at hand for power, a generating plant may be installed in a convenient place and power transmitted to the drills by wires.

This drill has all the capacity and wearing qualities of a standard Ingersoll-Rand Rock Drill, but uses only about half the power.

Each "Electric-Air" Drill is a complete unit, independent of every other, and may be located anywhere on the work.

No special skill is needed in running it. Any good drill runner will operate it at good efficiency.

High altitude rock drilling problems are best solved by the "Electric-Air" Drill, the electric power being available also for other work.

Shall we send Bulletin 4109?

Products :

AIR COMPRESSORS
ROCK DRILLS
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ELECTRIC-AIR DRILLS
CORE DRILLS
COAL CUTTERS
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CASSIER'S MAGAZINE

The War Against Dampness

THERE are various natural elements which have the reputation of being good servants but bad masters, and among these we may enumerate both fire and water.

Leaving aside, for the present, the subject of fire, it may be of interest to examine the manner in which water may do harm and the methods by which it may be kept under control.

Of course, the most obvious danger to be apprehended from water is that which is due to its presence in excessive quantities, to the action of floods, freshets and washouts. When, by reason of rapid thaws, by excessive rainfall, or by some miscalculation of construction, a vast volume of water fills a valley, river bed or structure to excess, the injury is not only great but is obvious and apparent. It is this very publicity of action which renders such troubles capable of being fought successfully and brought under control. The surface freshet can be met by proper provision for drainage, the weak dam can be strengthened, the torrent can be regulated and controlled, since the action of the water is open and evident and indicates the best methods for its own management.

There is another manner in which water may work injury, often more insidious and dangerous than by excessive quantity, and that is by its presence in the wrong place, by the production of dampness where dryness is essential to success. The ability of moisture to penetrate into walls, through masonry and up through foundations is well known to every builder and constructor. It permeates through brickwork, it seeps through the pores and voids of concrete, and it even passes the particles of apparently solid stone. Hence arises the danger to health, due to dampness in buildings; from this cause comes the damage to masonry structures when, after wet weather, the frosts of winter exert their expanding and rending action upon the stone, cement and mortar into which the water has pene-

trated, injuring them often beyond repair.

To many people the idea that concrete, for instance, is penetrable by moisture comes as a surprise, and many a person who has made plans for a concrete dwelling is incredulous when it is hinted that, unless he has made provision for waterproofing, he may find himself in possession of a building almost uninhabitable in wet weather. Concrete becomes practically like stone, and stone seems solid enough to keep out dampness; but experience has taught otherwise, and experience has also placed the remedy in the builder's hands. There are stones which are impervious to moisture, and it is their property which shows the true methods of fighting dampness. When the concrete is supplied with an insoluble silicate capable of filling all the pores and voids, binding the whole into an impervious mass, the dampness has been successfully fought, and is compelled to remain without, where its capacity for harm is neutralized.

This is, undoubtedly, the best method of fighting dampness in a concrete structure—to mix the waterproofing substance with the concrete when it is first made and thus secure a solid, waterproofed mass from the start. We have noted, however, that in many instances the necessity for waterproofing does not at first appear, and the dampness must be fought after the structure is completed. Here, however, it is not too late, since a waterproofing solution can be applied to the surfaces of the walls or foundations, either externally or internally, and, finding its way to the same places where the dampness would have penetrated, it thus forestalls it and is waiting to oppose and check its advance. Scientific methods of waterproofing, therefore, act in a logical and reasonable manner, using a water-fighting solution to reach the very places to which the water itself would otherwise get, and then solidifying there, to repel any further advance of the dampness.

To make

CONCRETE

and other surfaces

WATERPROOF

Follow this
Prescription

and satisfactory
results will be
assured.



Trade Mark
Registered

LAPADAS

A COMPOUND of silicate base, mixed with the mixing water, thereby becoming part of the concrete.

R

For dampness and like troubles due to ordinary cement construction:

INTERNAL USE

Take Lapadas dissolved in the mixing water. Mix well before using.

EXTERNAL USE

Apply Soloto to affected surface as required.

Dr. S.

Dissolved in water, goes everywhere water does.

IDEAL for the lining of heavy concrete structures and positively prevents the entrance of water.

tures and positively prevents the entrance of water.

Specify a Waterproofing that appeals to reason.

DOES it seem reasonable that, with ordinary labor, you can mix a dry powder evenly with cement, sand and gravel?

UNLESS it is mixed evenly, so that it reaches every part of of the concrete, the waterproof is useless.

WATER reaches every molecule. If it does not there is no bond at all.

LAPADAS is dissolved in water and goes everywhere water does. Does that sound reasonable?

"FACTS ON
WATERPROOFING"
FREE ON REQUEST

F. WM. STOCKER & CO. Inc.
34 West 33rd St., New York, N. Y.

Sure-Footed Sanitation

(Concluded from page 43.)

Employers are now by law required to safeguard the welfare of their servants by properly protecting them from the danger of machinery in motion, by well-designed stairways with landings at proper intervals and by the proper heating, lighting and ventilation of work rooms. Slippery or otherwise dangerous stairways, entrances or areas, are sought out and a remedy applied, either voluntarily or as a result of a visit from a liability insurance or building inspector. The steps of subways, surface and railway trains are generally covered with non-slip substances of various sorts, that we may enter or depart safely and in order. Let a slip or fall take place, resulting in injury to some unwary pedestrian, and if on a thoroughfare an officer most likely appears, pad and pencil at hand, to report the circumstance, in addition to rendering such aid as may be required. If that spot is reported dangerous, repairs by the authorities are made forthwith; or if a similar mishap occurs in a public building, the superintendent or custodian is sure to be called upon for a report and his measure of responsibility doled out accordingly. If the architect has erred in creating a poorly-designed entrance, step or stair, alterations ensue to remedy the evil, and so it goes until the work of pulling down, constructing, improving and replacing worn-out materials continually engages our attention. As a result the varieties of schemes, substances and devices designed for our safe conduct are legion—wood, granite, marble. Metals alone or in combination with other substances are utilized, together with rubber of various qualities and form, all having their points of excellence, as well as their shortcomings. Still the search continues for a better attainment than the last thing used, regardless (in most instances) of ex-

pense, as public buildings and conveyances to-day must be safely entered and found clean when entered, in order to suit the wise exactions of a critical public. The field thus created for the exercise of ingenuity and inventive ability in matters appertaining to even these apparently minor considerations have proved both interesting and profitable to those whom experience has privileged the study of these matters. We now realize that a soft pine floor, representing perhaps, the lowest first cost, has not been able to hold its own in competition with its many substitutes, some of which cost thirty times as much. Likewise, the iron scraper at the door, costing but a trifle, has given way to its various substitutes, each more expensive than its predecessor, until now it is both wise and possible to tread a safe, sanitary and ornamental entrance (with the dirt left outside) and obtain a welcome reception from those whose forefathers insisted that the shoes of callers be left at the door. We are, nevertheless, still invited to leave as much of the dust and grime of travel as possible at the portal when entering the various conveyances or structures provided for our accommodation. Since nothing second-class in durability, appearance or effectiveness can hope for recognition, it is generally conceded that movable floor coverings in some form of a rubber mat or rug contribute a larger share toward the slightly appearance and cleanly condition of numerous busy centres than any other material in general use. Recognizing the lack of, and demand for, still more substantial and attractive goods, some of which are of the character described, the Essex Rubber Company has devoted both time and energy, money and originality, in adding a few to the thousands of articles made of rubber in these United States, many of which are now well nigh indispensable to our health, safety, comfort, profit and pleasure.

NOTES

Improved Methods for Safety of Mail Matter

WHEN one considers the vast and constantly increasing volume of matter of every description which passes through the mails, including as it does articles of nearly every description, size and nature, one cannot but be impressed with the fact that such a very small amount of it fails to reach its destination safely. Without doubt this is due to the modern methods used in its handling, sorting and forwarding, as well as the care and pains bestowed upon it.

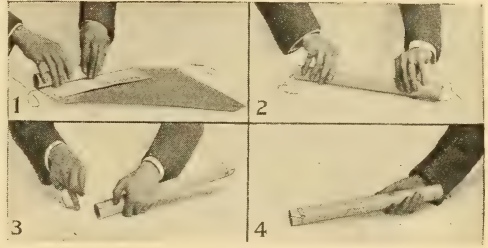
On the other hand every one calls to mind occasions when they have received either drawings, plans, photographs, pictures, blue prints or similar articles in such conditions as to make them practically worthless.

How often printed matter of beauty and interest, sometimes needed for immediate use, has come to hand in bad order, through no fault of the post office, but due entirely to lack of careful wrapping on the part of the sender! In fact, it is almost always the case that when an article is received in damaged condition, thereby causing inconvenience, trouble, and more than often, financial loss, the entire fault lies with the shipper.

The manufacturer who has expended time and money for handsome advertising, the engineer or architect in mailing plans, drawings and blue prints, and all who mail photographs, etc., desire to feel sure that they will reach their destination in as good condition as when mailed, and yet how often are they able to be sure that they will with the prevailing methods of packing such matter.

One of the latest and in many ways the best device for such use that has recently been placed on the market, is called the mail wrapper tube, which, unlike the ordinary tubes, which require much storage space,

come in flat sheets, thus taking up a very small amount of space for storage.



THE MAIL WRAPPER TUBE

"The Mailing Tube that Comes in a Flat Sheet."

This convenient wrapper-tube is made of news-board in various weights, cut in flat sheets at such a diagonal, then when rolled it makes a strong and perfect tube. The enclosure is rolled with this wrapper-tube in such a way that it is locked in and cannot be lost in the mail, yet it can be easily and safely removed upon receipt by simply loosening the cords which fasten its ends.

Made as it is in any length and the diameter being adjustable and coming flat, thus affording ease in addressing and avoiding all necessity of a label, it has met with a hearty reception and has been adopted by large publishing and printing houses, manufacturers and departments of the United States Government, not only for its strength and convenience, but because it is attractive in appearance and adds to the effectiveness of advertising matter by conveying a good impression on its arrival. In short, it is a device which is an aid to the post office and a convenience to the users.

This wrapper tube is manufactured in New York and the Hi-Lo Desk Company, 1726 Tribune building, New York, are selling agents, and they will be glad to furnish samples and full information to those interested.

Woodworking Machinery

We have received from the J. A. Fay & Egan Company, W. Front street, Cincinnati, Ohio, a copy of "Catalogue No. 84," just issued from the press. This catalogue illustrates and describes a very extensive line of standard woodworking machinery, which the company makes in such variety as to meet a wide demand. The catalogue consists of 384 pages and measures $5\frac{3}{8} \times 7\frac{3}{4}$ inches in size. It is profusely illustrated, the engravings being for the most part direct reproductions from photographs of the machine, and these are accompanied by such descriptive particulars as will enable the woodworker to readily comprehend the salient features of the machine in question. The work is in effect an unabridged, condensed form of the company's general catalogue, which we understand will be sent, charges prepaid, to any address on application. The company points out that it makes a specialty of every class of machine illustrated and described in the catalogue, and that it supplies single machines or complete outfits for every kind of woodworking plant as may be required. The large catalogue referred to contains about 500 pages, consisting of 24 sections, dividing the company's tools and appliances into groups, each group containing only machines of similar designs and purpose. The "Catalogue No. 84," at present under review, will be found of special interest and value to the woodworker, whether his operations be conducted upon a small or a large scale, as it will prove an excellent work of reference in his line.

It is expected that the American pavilion in the "Valentine," the site for the Universal Exposition to be held at Turin, Italy, next year, on the banks of the river Po, will be one of the finest and most artistic among the foreign buildings. Its construction is already far advanced.

Compressed Air for Industrial Purposes

Every business man is interested in a device which will simplify his work and reduce costs, and will, therefore, be glad to read the new book issued by the Allis-Chalmers Company, of Milwaukee, Wis.

The introduction of the use of compressed air in machine shops to operate air lifts, air drills and riveting hammers, and as a blast for blowing dust from the surface of the work and from parts of machines; in the forge shops, in the furnaces and annealing ovens; in the foundry for rammers and chippers; in the power house for blowing the dust from generators, etc.; in the textile mill for cleaning frames and spindles; in such work as the cleaning of delicate apparatus, switches and electric windings, and in the many other purposes for which it is so well adapted, has done much to lessen expense and, at the same time, give rapid and satisfactory results.

The book takes up fully the stationary and portable motor-driven compressors which this firm is now building in sizes of from 11 to 50 cubic feet of free air per minute, and for which there is such a large demand. These compressors are built in the most compact form possible, and the same care, both in design and construction, which has made Allis-Chalmers products of all kinds so well and favourably known is expended on them. The large experience gained by this company in building air compressors and compressors and air brakes which are used on a large majority of the electric cars using air brakes throughout the world well fitted it for the perfecting of stationary and portable motor-driven compressors for other work, and has resulted in a combination unequalled for sturdiness of construction and satisfaction of operation. The book is interesting, and will, without doubt, meet with a large demand. A copy can be obtained by addressing them.

NOTES

Personal

J. E. Waggoner, M. E. A. E., Professor of Agricultural Engineering in the Mississippi Agricultural and Mechanical College, has been appointed to the I. H. C. Service Bureau, recently established by the International Harvester Company of America.

The company is desirous of promoting the healthy growth of farming in every way possible, and to this end it has made arrangements to answer all questions and help solve the problems of the farm, to co-operate in the work of agricultural colleges, experiment stations, and the United States Department of Agriculture, and to assist in the collection, correlation and dissemination of general agricultural information. The entire service is free. Research work along independent lines will be conducted, and the results of such scientific investigation will be placed at the disposal of all students of agriculture.

Professor Waggoner is a graduate of Iowa State College of Agriculture and Mechanical Arts. The course at the Ames School is the only one in the United States which confers the degree of Bachelor of Science in Agricultural Engineering, and Professor Waggoner enjoys the distinction of having been the first to receive this degree.

Mr. F. H. Clark, General Superintendent of Motive Power of the Chicago, Burlington & Quincy Railroad, delivered an address before the students and faculty of the College of Engineering of the University of Illinois on Thursday, November 3. His subject was "Problems of the Motor Power Department." Mr. Clark is a graduate of the University of Illinois with the Class of 1890.

Mr. Howard E. Coffin, president of the Society of Automobile Engineers, has announced that the annual meeting of the S. A. E. will be held in New York City on Wednes-

day and Thursday, January 11 and 12, 1911. The two days' sessions will be devoted to the business of the society and to technical subjects, upon several of which papers will have been printed and distributed in advance of the meeting.

Professor Joseph W. Richards, of Lehigh University, recently presented a paper on "Electric Power Required to Melt Metals" before the American Brass Founders Association.

One of the Greatest Essentials in Typewriting Construction

One of the greatest essentials of a perfect typewriter is the carriage. It is necessary, in order to attain perfection, to have a perfectly rigid printing point at the time of writing, but at the same time the carriage must be smooth or easy running. This is impossible in a typewriter that has to shift the carriage either up or down, back or forth. In the machine manufactured by the Monarch Typewriter Company, of New York, this difficulty is overcome, since it does not shift. It is absolutely rigid, and as all its joints are solid, there is no looseness anywhere; in fact, nothing to get loose.

Their new publication "Monarch Light Touch" describes their machines and their good points, both in design and construction, such as their typebar segment, typebar, ribbon movement, etc. A copy can be obtained by writing them.

The Ingersoll-Rand Company, 11 Broadway, New York, has acquired an important addition to its manufacturing interests in the purchase of the property and business of the A. S. Cameron Steam Pump Works, whose plant is located at the foot of East Twenty-third street, East River, New York. The pump company is enjoying an active trade, and its plant is running on full time.



FINANCIAL NOTES OF THE INDUSTRIAL WORLD

The Largest Factory in the World Devoted Exclusively to the Manufacture of Adding Machines

The great growth of the business of the Burroughs Adding Machine Company is clearly indicated in the following facts: Machine conceived in 1882; developed from 1882 to 1888; cost of first machine \$300,000; first machine marketed in 1889, and first 150 machines recalled and destroyed by inventor in 1891. From 1891 to 1895 1,000 machines manufactured and sold, and from 1896 to 1900 nearly five times that number made and placed on the market. From 1900 to 1906 the increase in production was as follows: 1,500, 2,121, 3,102, 4,445, 5,088, 7,804 and 12,000 machines. Their present plant was built in 1904, and, two years later, the rapid increase in the demand for their machines necessitated its increase 60 per cent. The capital stock of this company is \$5,000,000, and they have nearly 2,000 employees, while their machines are known and used throughout the civilized world, and one of their machines is sold every fifteen minutes of each working day.

\$60,000,000 to be Expended by the Italian Government for Pure Water

As a result of a report made by the National Board of Health, which says that the cholera epidemic may have begun in the Apulia region on account of the bad quality of the water there, the Government will ask Parliament to vote an extraordinary credit of \$60,000,000 for the immediate construction of dams, aqueducts and artesian wells, to provide the cities and villages of Apulia with a good water supply.

Great Quantities of Zinc Ore in Tennessee Only Await Capital for Their Development

Recent developments have demonstrated the possibility of profitable mining the bodies of low-grade ore 40 to 50 miles long and hundreds of feet wide. The State Geological Survey has just issued a bulletin of less than twenty pages, dealing with the mining of zinc in Tennessee. The paper is illustrated, and was written by Samuel W. Osgood, of Knoxville, who has been associated with zinc mining in the Joplin and Galena districts, and, more recently, in the East Tennessee district. The paper refers briefly to the character and geology of the ore, then discusses the past history of zinc mining in Tennessee, and points out the causes of past failures; then it describes recent experimental developments on a much larger scale than had heretofore been attempted, with results that led Mr. Osgood to believe that the profitable development of the ores have been demonstrated.

The ore is of a low grade, though higher than the Joplin, Mo., ore, and Mr. Osgood believes that the key to the situation is simply the working of the deposits on a large enough scale to permit of the use of labour-saving machinery, so as to reduce the per ton cost of mining and milling the ore, and he gives the figures upon which his conclusions are based. He also gives figures to show that the smelting of Tennessee ores in Tennessee should prove a very profitable business when properly carried on.

It is only another case similar to the copper situation at Ducktown, where a deposit that could be worked on a small scale only at a loss will yield a handsome revenue if worked

FINANCIAL NOTES

on a large scale with proper machinery. The same thing is true of much of the mining operations on the metalliferous ores everywhere to-day. A large share of the metals is to-day obtained from low-grade ores by the use of up-to-date machinery that could not have been profitably mined a few years ago. It is believed that ultimately Tennessee will be found to possess many other low-grade deposits that will be workable only when capital to the extent of at least several hundred thousand dollars is invested in their development.

Opening for Electrical Material in Mexico

Mr. William W. Canada, U. S. A., Consul at Vera Cruz, Mexico, calls attention to a most attractive opening for the establishment of an American agency for electric material of all kinds at Vera Cruz. He states that, as it is now, the goods arrive at Vera Cruz and are then forwarded to Mexico City, whence they are again brought back to this city. The buyer is, therefore, compelled to pay a higher price for his goods, which, if this were not the case, would certainly increase the sales of all electric material in this city and vicinity.

In speaking of the centennial celebration, he remarks: "This is the first time in the history of Vera Cruz that the city has had a general electric illumination. The demand for material has, therefore, been unprecedented; in fact, the supply in certain lines was entirely exhausted. An American agency for electric material of all kinds ought to be established at this port, as the use of electric signs for advertising purposes will become general after the festivities mentioned.

French Bankers Obtain Control of 1,875 Miles of Railroad in Brazil

In connection with the important articles on "The Railways of Brazil," by Lionel Wiener, which are appearing in this magazine, it is of in-

terest to note that a contract has recently been signed by the Minister of Public Works and a syndicate of Paris bankers giving the latter a lease of the Federal railroads in the State of Bahia and providing for the construction of extensions of the line.

The French bankers obtain control of 1,875 miles of railroad. The cost of the extensions is estimated at \$35,000,000, payable in Federal bonds.

Annual Report American Steel Foundries Company Shows Largest Gross Earnings Since 1906-7

The report of the American Steel Foundries Company, New York, for their fiscal year ending July 31 last is interesting, and shows large gross earnings. In addition to the financial statement for the twelve months' period, the report gives figures for the last five years, some of which we give below.

Gross sales, 1909-10, \$17,173,740; gross earnings after deduction for costs and management, \$1,896,072; net income applicable to surplus, \$1,030,220, this being the remainder after deducting all charges, including repairs, maintenance, depreciation and sinking fund, the total of such deductions being \$1,718,246.

During the year \$138,500 from the sinking fund of first mortgage bonds were bought and retired. The gross sales of 1909-10, as given above, are \$10,035,732 larger than those of last year, but are still below the 1906-07 record figures for yearly sales of \$19,463,521.

Union Switch & Signal Company to Increase its Capital Stock

The Union Switch & Signal Company is going to increase its capital stock from \$2,500,000 to \$5,000,000, and the directors will be authorized to issue the new stock either in the form of dividends or for subscription. The special meeting of the stockholders to act upon the proposal will be held in Pittsburg on December 14.



THE LATEST CATALOGUES

Locomotives for Passenger Service

Record No. 67, an attractive work just to hand from the Baldwin Locomotive Works, Philadelphia, Pa., illustrates and describes fourteen locomotives recently built by them for passenger service. The designs shown include several wheel arrangements covering a wide range in weight and capacity. The types shown are engines built for the Missouri, Oklahoma & Gulf Railway, the Atlanta, Birmingham & Atlantic Railroad, Baltimore & Ohio Railroad, Idaho & Washington Northern Railroad, Atchison, Topeka & Santa Fé Railway, Seaboard Air Line, Great Northern Railway, Oregon Railroad and Navigation Company, St. Louis & San Francisco Railroad, Illinois Central Railroad, Alabama Great Southern Railroad, Chicago, Burlington & Quincy Railroad and Northern Pacific Railway.

Descriptions are given of the particular class of work each engine was designed for, as well as their general dimensions. Copies can be obtained on request.

"Points of Excellence About the Burroughs Adding Machine"

In a handsome little book with many illustrations the Burroughs Adding Machine Company clearly sets forth twenty-eight points of excellence in their well-known adding machine. The book is of interest, and can be obtained by addressing their New York office, 220 Broadway.

Recording Thermometers

Bulletin No. 126, recently received from the Bristol Company, of Waterbury, Conn., is devoted to their Class II recording thermometer, and describes same clearly by well-written

text and many illustrations, and appended to which is a partial list of users which gives over 300 representative firms in different industries. An important application of this instrument is for recording temperatures of feed-water for steam boilers, which makes these thermometers of general interest. On pages 16 and 17 is given an actual record of temperatures in a sulphite pulp digester, this being the first time such a record has been reproduced.

The Bristol Company will be glad to send a copy to anyone interested who mentions this magazine.

Switchboard Indicating Meters

The Westinghouse Electric & Manufacturing Company has just issued its Circular 1,098 on the subject of Switchboard Indicating meters. The publication outlines the cardinal points to be kept in mind in the selection of meters. It describes direct current and alternating current indicating meters, including frequency meters and power factor meters, synchroscopes, and instrument transformers. It is pointed out in the circular that, with the development of switchboard design, has come the necessity for various types and forms of indicating meters, each adapted to its own peculiar purpose. Meters amply accurate for one class of service might prove entirely unsuited for another service, while high-grade meters are, in general, too expensive for use where accuracy is not of prime importance.

With the introduction of meter or control boards forming units separate from the switching apparatus and bus-bars, a need has arisen for meters with long scales and long-distance readability. The organization of

LATEST CATALOGUES

large power developments has necessitated the introduction of the edge-wise type of meter, which occupies small space and yet retains the long scale necessary for accurate legibility. For these uses meters of high accuracy are essential. On the other hand, for small power plants, battery charging plants and similar installations a cheaper instrument will serve the purpose admirably.

Engine Type Continuous Current Generators—Forms RB and RBO for Lighting and Power

A bulletin was recently issued by the General Electric Company entitled "Engine Type Continuous Current Generators, Forms RB and RBO for Lighting and Power." The bulletin illustrates and describes direct current generators for two and three-wire systems from 25 to 250 kilowatts and for standard voltages.

Adding Machines

The little book, "A Better Day's Work," issued by the Burroughs Adding Machine Company, Detroit, Mich., contains much interesting reading for every man who employs help to help him make money, for the man in a responsible executive position, and also to the man in a minor position, who realizes the only way to make more money is to make himself worth more. The Burroughs Company will be glad to send a copy on request.

Dynamo Lighting System for Automobiles

From the Ward Leonard Electric Company, Bronxville, N. Y., comes a fully illustrated booklet, showing methods of mounting the Ward Leonard automatic dynamo lighting system for automobiles, which they claim is a thoroughly reliable source of electricity on the car. A dynamo located under the hood or in some similar position keeps storage batteries constantly charged, so that

when the car is standing still the storage batteries supply the current for lighting headlights, sidelights, rear lamp, speedometer light, electric horn, cigar lighter, etc. When the car is running at a speed of 10 miles per hour or over the dynamo supplies the current for these devices and charges the batteries.

The system requires absolutely no attention, except occasional oiling and adding of water to the batteries.

Catalogues and full information can be obtained by addressing them.

From Harper & Bros., publishers, New York, are received handsome lists of holiday books and of their recent publications.

Recent catalogues have been received from the General Electric Company, of Schenectady, N. Y., treating of hand-operated starting compensators for alternating current motors, isolated plant, direct-current combination generator and feeder panels, electric automobile appliances. From the Bristol Company, Waterbury, Conn., on their indicating thermometers, long-distance recording tachometer, radii averaging instrument and round form of recording pressure gauges; from the North Western Expanded Metal Company, of Old Colony Building, Chicago, describing the use of their expanded metal for reinforcing concrete; the Cutler-Hammer Company, regarding their lifting magnets; the Goodrich Rubber Company, of Akron, Ohio, describing their well-known tires; the Essex Rubber Company, of Trenton, N. J., covering their line of rubber engineering specialties, and the Amberg File & Index Company, 81 Duane street, New York, entitled "Modern Filing Systems." Copies of these publications can be obtained by addressing the company issuing them and mentioning this magazine.

Pushing and Pulling

IT has been wisely observed that most operations can be more efficiently performed by drawing them along through their proper course than by attempting to push and jam them through, just as it is much easier to pull a rope than it is to push it. There are probably not many persons who have tried to push a rope, but very many have attempted things almost as perverse. In many manufacturing establishments, for example, there may be seen numerous examples of men wasting a large part of their energy endeavoring to move heavy pieces of work upon small trucks, pushing and labouring in the exertion of effort, a small fraction of which goes to cause the actual progression. Even when such an effective aid to transport as an industrial railway is installed, it is often used at less than its proper efficiency, because there is too much pushing and not enough pulling.

No doubt it is easier for a gang of men to push a truck along than for them to pull it; but when the load is heavy enough to require the effort of a gang it is too heavy for human effort at all, and proper management provides mechanical propulsion for such service. We all are beginning to realize that mechanical traction is superseding animal power in all departments of transport, and that electric traction is replacing other kinds of power for very many departments of such work.

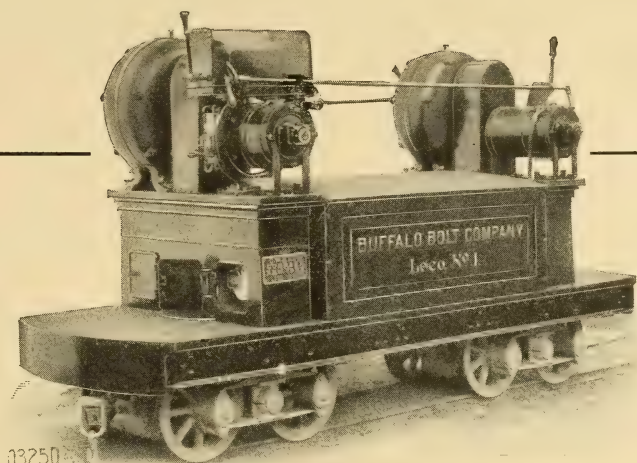
Electric traction is practically supreme for street-car service in all parts of the world, and it is rapidly becoming the principal form of power for main-line railway service at and near the great terminal points. Its numerous advantages need not be specified for these purposes; they are self-evident.

In the manufacturing establishment of the present time there is nearly always a supply of electric current, used both for lighting and for the operation of machinery. There is, therefore, no reason why electric

traction should not be used for transport as freely as it already is for the driving of tools. The electric traveling crane has already become a standard appliance for the transport of overhead burdens within the limits of those portions of the works which it can serve, and electric hoists have their useful applications. For the industrial railway, however, the electric locomotive offers by far the best appliance for pulling the load to any portion of the establishment.

In installing electric traction in a machine shop it is essential to consider the necessity of reaching any point to which the track of the industrial railway can be laid. This means that any system which demands that the electric locomotive receive its current from a fixed conductor, such as an overhead trolley wire, or from a third rail, is most undesirable. The electric locomotive should be self-contained and independent of anything except the track upon which it runs, which means that it must carry its own supply of electricity with it, operating upon the storage battery system.

The storage-battery locomotive is especially adapted for service in manufacturing establishments for several reasons. The discontinuous nature of the work gives abundant opportunity for charging the batteries, so that the machine is always available for duty. The simplicity of the apparatus renders it capable of operation and inspection with ease, while the range of speeds covers all practical requirements. The cost of operation is incurred only when in active service, and hence the expense bears a direct relation to the amount of work done, while the saving in the cost of labor renders the machine one of the most profitable investments which can be made. When it is demonstrated that twenty-five men are required to do the pushing which one man and the machine had been quietly effecting by pulling, it should be an easy matter to determine the value of such an investment.



HUNT STORAGE BATTERY LOCOMOTIVE

21½ inches gauge

ONE of the best types of Labor Saving Machinery is the HUNT ELECTRIC STORAGE BATTERY LOCOMOTIVE.

With it one man can handle all the material in a large Manufacturing Establishment.

It runs around curves of 12 feet radius as easily as a wagon turns a corner, making readily accessible every part of the works, and easily hauls the loaded cars up the grades frequently found in establishments that have grown by successive additions.

No trolley wires are required, and there is no expense on holidays or when work is slack.

We will be pleased to correspond with those interested in reducing the expense of handling their materials.

**Hoisting and Conveying Machinery, Cable Railways,
Automatic Railways, Steam Shovels**

C. W. Hunt Co., West New Brighton, N. Y.
N. Y. City Office, 45 Broadway

Atlanta, Ga., 607 Rhodes Building
Richmond, Va., State Bank Building

Chicago, 1616 Fisher Building
San Francisco, 865 Monadnock Building

The Pull of Electricity

MANY hundreds of years ago it was discovered that a piece of magnetic stone could lift to itself small pieces of iron, and from that phenomenon and from the discovery that this magnetic action was similar to the manifestations of electricity there has been developed all the tremendous industrial applications of the electric current.

The conversion of the electric current into mechanical energy means its transformation from a silent force flowing through a stationary wire into foot-pounds of work; into the lifting of a weight; into a pull upon a hoisting tackle for useful service.

It has taken a long time to convert this silent electric current into an obedient service, and for many years it was kept only for lecture-room demonstrations and scientific experiments. Mechanical hoists of varying degrees of efficiency, culminating in the Triplex block, which converts 80 per cent. of the power delivered to it back in the form of useful work, have been produced, and are in use for all kinds of lifting, but these require that human energy be used in the first place, and while most effective within their limits, have definite limits which may readily be understood.

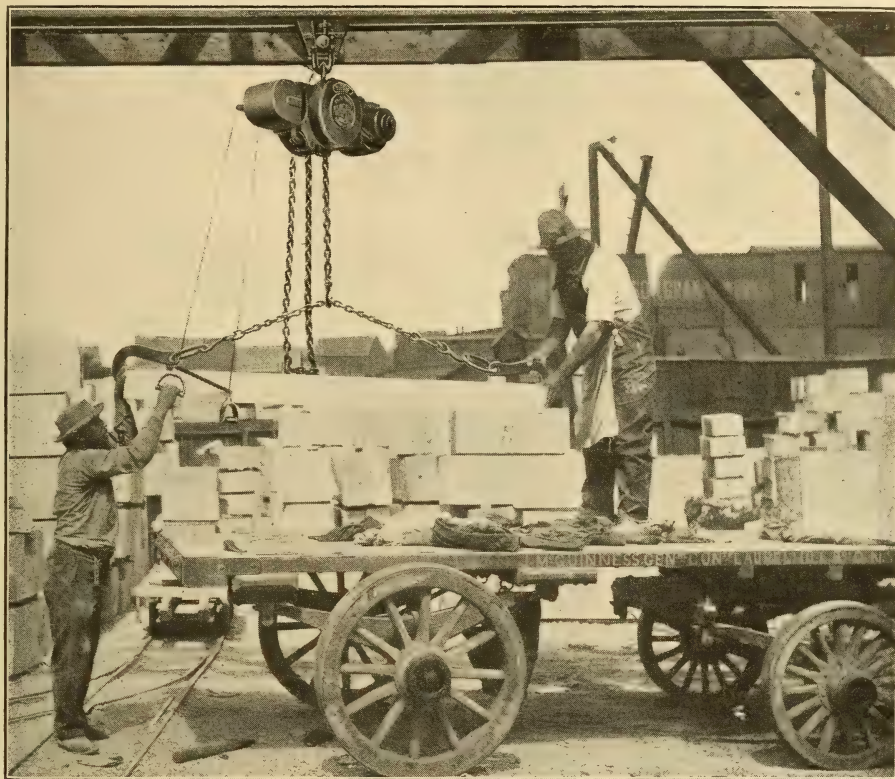
In applying the electric current to modern mechanism for the lifting of loads it might be supposed that some special apparatus would have to be designed to meet the changed conditions of service, but it has been found that no more effective mechanism could be produced than had already been devised in the form of the Triplex block, and that the simplest and most generally adaptable apparatus consisted of the original Triplex block with an electric motor substituted for the effort of a man at the end of a chain.

A hoist by itself is an appliance of limited opportunity; it can lift what it can reach, and it can lower upon points beneath its range. When, however, it is combined with a trol-

ley and overhead tramrail its capacity at once becomes extended indefinitely. It can lift anything within its capacity, and with the electric Triplex that capacity extends up to twenty tons. It can go anywhere that the tramrail from which it is suspended can be run; in the works, through the yards, into the warehouse.

With the increasing cost of human labor, the engineer is obliged to devote much of his attention to the reduction, not of the wage which the individual workman receives, but to the diminution of the labour cost of the unit product. A man may well receive higher wages if, by the development of his skill and by the introduction of improved appliances, his productive capacity is also increased. It is the cost of the amount of labour which goes into the salable product which determines the actual labour cost, and this is largely controlled by the efficiency of the mechanical appliances with which the man does his work.

Thus, with an electric Triplex block one man can handle a load in one-third the time which he would require with a hand hoist, so that his efficiency is increased nearly three times, the only charge against this service being the interest and depreciation on the cost of the apparatus and the charge for the electric current. This means that the labour cost of the operation is only one-third what it would have been under the older conditions, and in computing costs such elements must enter. The up-to-date concern, which keeps its labour costs down, not by reducing wages, but by increasing the efficiency of its employees, is in a position to command the market and at the same time keep its workmen well remunerated for their efforts. The true solution of the labour problem thus appears in the art of enabling the man to help himself to higher efficiency by providing him with appliances of such efficiency as to increase his value to his employer.



The quickest way ever devised for loading or unloading heavy material

Silent Force vs. Main Strength

WITH an Electric Triplex Hoist a man can lift any load up to twenty tons in one-third the time required with a hand hoist.

When his Electric Triplex Hoist is hung from a trolley, he can also push the load wherever the trolley goes—from one part of the works to another—on the car—or off the car.

To sum it all up, it is perfectly fair to say that with an Electric Triplex Hoist one man does the work of three.

We have a book about Electric Hoists which we should like very much to send you. All we ask is your name on a postcard.

Chain { 4 Styles: Differential, Duplex, Triplex, Electric.
Blocks { 42 Sizes: One-eighth of a ton to forty tons.
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CASSIER'S MAGAZINE

Both Ends and the Middle

IN designing the equipment of a power plant there is often seen a tendency to devote a disproportionate share of attention to the extremes of the system and to neglect the intermediate details. Thus, the power-generating end has formed the subject of the study of the ablest engineers from the time of Watt to the time of Corliss and of Parsons. The steam consumption per horse-power has been reduced until it has become evident that, if greater economy is to be secured, some other medium than steam must be used in the conversion of the latent energy of the heat into the kinetic energy required for utilization. Speed regulation has been perfected until it is a question, not of the variation in the number of revolutions, but of the acceleration and retardation during a single revolution. Problems of balancing have been solved within the practical limits of construction, while friction, radiation and condensation losses have been reduced to a minimum.

At the other end of the line the innumerable applications of mechanical power include such a variety of ingenious and efficient machines that it is impossible to enumerate them. The entire line of machine tools for cutting and forming metals includes some of the most ingenious productions of inventive genius. When to these we add all the applications of the electric current, all the hydraulic, pneumatic and dynamic appliances well known in the workshop, we have but imperfectly covered the immense field of power-using devices. Thus, at both ends of the chain we find machines of the highest order of efficiency, convenience and capacity. The power is generated to the best advantage within the physical limitations of the medium employed, and it is utilized in machines of marvelous variety and adaptability.

In many cases, however, we find that the intermediate element in the system, the delivery of the power from the generator to the tool, is

given proportionally far less attention. In consequence, this portion of the installation is operated at a much lower efficiency than the extremes between which it is placed. In by far the greater number of establishments the transmission of the power is still affected by the use of shafting, pulleys and belting. This means the employment of journal bearings of various kinds, pillow blocks, hangers and supports, the combination giving abundant opportunity for the production of excessive friction losses and the reduction of efficiency. The employment of pulleys and belting, or of grooved sheaves and rope transmission, gives another entrance for defective equipment, while the use of clutches and similar devices further extends the possibilities.

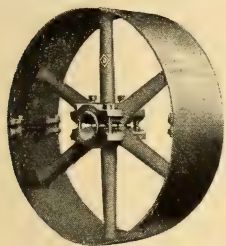
We say the possibilities, because with these very appliances there exists a possibility, both of poorly designed and inefficient equipment or of a highly efficient and satisfactory arrangement. There is no reason why a transmission system extending between the engine and the tools should not be as complete and effective as the extremes between which it is placed. It cannot be expected, however, that a transmission possessing high efficiency, smoothness of operation and durable action can be secured by gathering the material at haphazard and allowing it to be assembled by the ordinary mechanic. The modern transmission engineer has made as much of a study of the perfection of his department of work as the engine builder has given to the saving of the last fraction of a pound of steam, or as the tool designer has directed to the performance of useful work.

When the power transmission is placed in the hands of the skilled specialist it will give results equal to those of motor or tool; otherwise, it will return only what has been put into it in the form of inexperience, ignorance, or unwarranted assumption about a question demanding the best specialized knowledge.

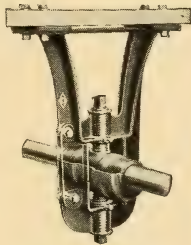
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What the Completeness of THE **DODGE** LINE Means to the Power User

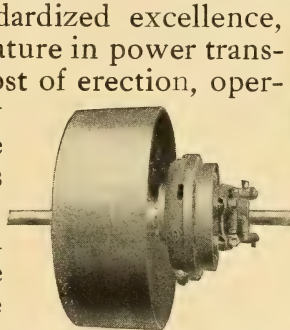
POWER Transmission machinery can now be purchased as are other standard products. ♦ It is no longer necessary to pick up different parts of the transmission system in different places—a pulley here, a hanger there, and a coupling elsewhere. ♦ The Dodge Line embraces “everything for the mechanical transmission of power,” so that all the transmission appliances in the shop may be of one uniform high standard of merit. ♦ All representing The Dodge Idea—standardized excellence, interchangeability and the split feature in power transmission machinery. Thus the cost of erection, operation and maintenance is greatly reduced. ♦ Moreover, The Dodge Line is carried in stock by branches and agencies all over the country, which insures you “what you need when you need it.” ♦ Please familiarize yourself with Dodge Appliances. Their installation puts your transmission equipment in the investment class.



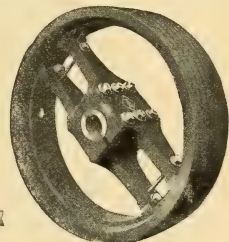
♦ Dodge “Standard” Split Iron Pulley with interchangeable bushings and set screws. Non-flexible, can’t bend. Bulletin C-128.



♦ Dodge Ball and Socket Drop Hanger—phantom view. Made on the true ball and socket principle. Each frame takes several sizes in various types of plain and self-oiling bearings. Bulletin C-115.

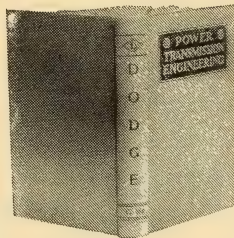


♦ Dodge Split Friction Clutch with Iron Pulley on sleeve. Bulletin C-116.



♦ This is the original Dodge “Independence” Wood Split Pulley. Made to use and to do hard work. Carried in stock everywhere in regular sizes with interchangeable bushings. Bulletin C-77.

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♦ We have just issued this new complete catalog No. CC-10, “Power Transmission Engineering.” More than 400 pages of data on power transmission machinery. Every owner, manager, superintendent, purchasing agent, master mechanic and chief engineer of power-using plants should have a copy. Write us or send the coupon for this catalog and other interesting information about the transmission of power.

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The Always-Ready Air Power Hoist

FOR industrial establishments of any considerable extent, a supply of compressed air for general power purposes—that is, for the numerous smaller and more scattered power requirements—may be said to have advanced its own status from at first that of a mere convenience to now an actual necessity, and the works which pretend to any standing or which boast any business enterprise and which have not a permanent and reliable supply of compressed air supplied to various uses are the exception rather than the rule. Compressed air constantly proves itself an excellent servant for light, widely separated and occasional services, and it shows itself perhaps at its best when used for hoisting. The direct-acting, single-cylinder, air hoist for its instantaneous readiness and its quickness and precision of action, is without a rival in its special field, while the geared motor hoist gives a control of the rate of lowering and hoisting and an absolute certainty of holding the load at any point and for any length of time which cannot be surpassed.

In the employment of compressed air for the driving of continuously-operated tools or machines, there is one particular condition which is generally imperative. It is necessary to have a continuously-running compressor, because it is not practicable to store the air in sufficient quantity to last for any length of time. With a compressor of a capacity adapted to its regular load, both production and consumption of the compressed air going on continuously and at an approximately equal rate, the compressor, with the air storage capacity usually provided, can only be said to be about a single minute ahead of whatever it furnishes the air to, so that if it should stop for a minute all the running machinery driven by it might be out of commission in the next minute.

This one minute of margin, how-

ever, constitutes a vast difference from and advantage over the electric drive, with which there is not a single second of margin. The generator must never stop if what it drives is not to stop. If the generator stopped an electric hoist would be as inert as a watch without a mainspring. When we see a street full of trolley cars stopped we know that the drive is dead at the power house. The wires will then not supply current to move a single car any more than to move all the cars on the line. When the generator is started again there must be current enough to move all the cars on the line, and this must be always kept ready for the work, no matter how irregular the cars.

For the operating of air hoists, one or many, and whether direct-acting or motor-driven, the possibility of air storage, although, as said, it is limited, is still sufficient to give the air hoist an important economic advantage. It really takes very little—reckoned in horsepower—for any single operation of hoisting, and the time required for the hoisting is very small when compared with the intervals of rest between, so that a very small compressor running continuously may supply not only one but several air hoists and without any excessive or expensive storage capacity. In shops where an air supply is maintained for operating pneumatic tools and for the numerous air-operated devices, now so common, especially in railroad shops, the consumption of air by the hoists is scarcely discoverable. To raise a ton five feet high in one minute requires only a half of a horsepower, with liberal allowance for friction and other losses, and this half of a horsepower may be furnished by a compressor of one-tenth of that capacity or less, allowing it to work right along through the intervals generally occurring between the hoists, while electric power would have to be all there at the moment of hoisting.

INGERSOLL-RAND CO.

NEW YORK **LONDON**

"IMPERIAL" HOISTS

SAVE LABOR COST

Introducing one or more "Imperial" Motor Hoists in your plant is like adding a gang of laborers who will work for nothing.

When it comes to the lifting and transferring jobs, one of these machines will do the work of several husky men; and the cost will be only the fraction of a cent for the air used.

But there is more to the question than this. The "Imperial" gives a steady, even pull which cannot be equaled with any chain block, or block-and-tackle.

It has no vibration whatever and is unequalled for delicate hoisting jobs where nice adjustments must be made, or where a jar would make trouble, as in handling foundry molds.

There can be no running-back or slip under load, for the worm gearing is an automatic lock rendering any brake unnecessary.

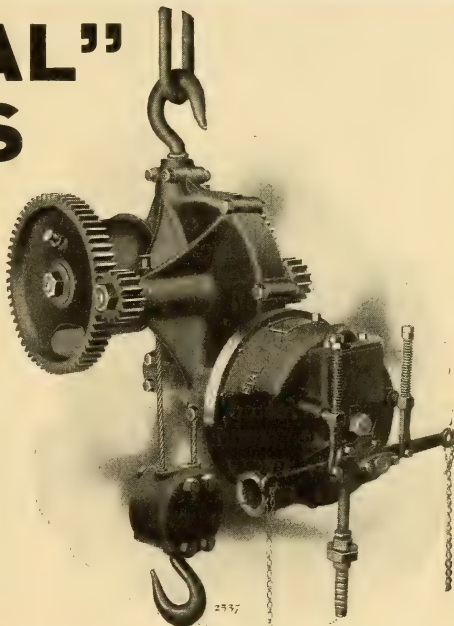
Brakes wear, or get greasy, and fail to work. But there can be no failure in the grip of the "Imperial" gears.

Perfect control is afforded; starting and stopping are instantaneous; speed of lifting or lowering can be adjusted to a nicety.

Added to all these operative advantages are a splendid design and construction which assure long life and maintenance of economical adjustments.

As a matter of fact, an "Imperial" Hoist will quickly pay for itself in the money value of the time, labour and floor space it saves.

You should certainly have Bulletin No. 8006.



Products :

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HAMMER DRILLS
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CORE DRILLS
COAL CUTTERS
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Yokohama

Modern Repetition Processes

IT is now well understood that the only method which can be successfully employed in the manufacture of such products as sewing machines, typewriters, and the like, is that which takes advantage of the possibilities of modern machine tools for the repetition of great numbers of individual parts of identical nature. It is not so well appreciated, however, that the manufacture of weapons is probably the most conspicuous example of this remarkable development of tool-making and tool-using.

When any new design of gun, for example, is under consideration, there is made first a "sample," upon which all the care and skill of the gun-maker is expended, and which, for a small arm, may cost as much as two thousand dollars. After the design has thus been perfected, a "model" is made, using the standard machine shop equipment, every detail being considered with respect to its performance as a weapon and every effort being expended to attain as near perfection as possible. Such a model will cost somewhere about three thousand dollars. This model is then studied from the point of view of manufacture, each piece being taken up and every process in its manufacture considered, so that special tools, jigs and fixtures may be designed. These special tools and appliances are intended to enable the parts to which they belong to be manufactured accurately, continuously and at the lowest possible cost, the product consisting of pieces so absolutely identical that they will be perfectly interchangeable without requiring any fitting or other work. With a plant equipped with machinery thus designed, and operated under proper organization, the gun which cost three thousand dollars as a single product of the ordinary machine shop can be manufactured in quantity at a cost of less than eight dollars.

Probably no better example of the commercial value of standardization applied to the production of a manu-

factured article could be given than the above bare statement of what is being done in the armories of the United States and in the government and private gun works of European countries equipped with American tools.

It is evident that such a method involves a large preliminary expense, and it also demands the existence of a market for an immense number of articles all practically alike. The market exists for many things of this sort, and it is being extended by the standardization of things which formerly were not so made. When the market exists the capital for the original investment in tools, jigs, and apparatus can usually be found. With both of these available, there is also required, however, something more, something which cannot be produced on call, something which is the progressive growth of technical and business development, and that something is the existence of a works in which is concentrated the experience, knowledge and ability to design and make the special tools upon which repetitive processes depend.

The idea of manufacture by repetitive processes and special machinery furnishing machines composed of interchangeable parts originated in the United States; being first adopted in Connecticut for the making of agricultural implements, followed by the manufacture of small arms, and then later extended to sewing machines, typewriters, bicycles and similar products. It is not limited to these things, however, but has possibilities far exceeding those now realized. The manufacturer of to-day who finds his costs exceeding his returns may well investigate the extent to which output can be enormously increased without any corresponding increase in operating expenses, so that the cost of the individual piece is correspondingly reduced by standardizing the product so as to permit the costly method of ordinary manufacture to be replaced by these repetitive systems.

RECORDING GAUGES

Recording Gauges

AN important part in economical production is performed by the recording gauge, which enables the plant owner to keep as accurate a record of work done in the boiler room as he does of his labor and other manufacturing costs, and to-day recording gauges are no longer considered a luxury, or an ornament, but are an absolute necessity to both the manufacturer and power-plant owner.

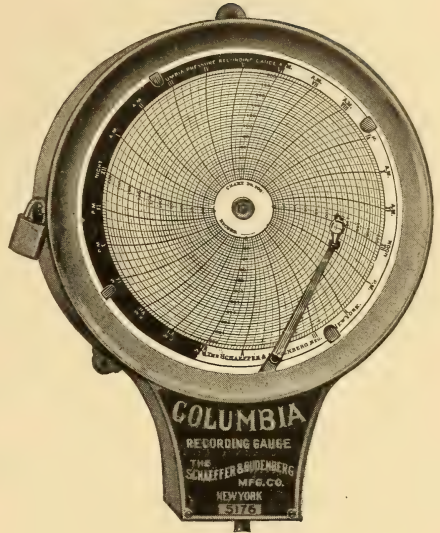
It enables the manufacturer to successfully compete in an open market—costs must be carefully watched and regulated, and the cost of power, playing as it does a most important part in the expense of production, is a factor which cannot be neglected.

Uneven boiler pressure means waste of coal and unsatisfactory delivery of power to the operating rooms, while unnecessary variation of pressure shortens the life of the boiler. Conscientious work in the boiler room contributes much to continuous, evenly directed and result-producing effort throughout the entire plant, and there is nothing that stimulates and compels conscientious work in the boiler room more than the installation of a properly-designed recording gauge.

The recording gauge may be called your insurance pressure gauge. The recording gauge, however, is not only your pressure insurance, but to a more or less extent your insurance of efficiency throughout your entire plant.

Not alone, however, for recording boiler pressure but for various other uses and purposes recording gauges are being used more widely each year. They are invaluable in the gas industry in furnishing records of the flow and distribution of gas to the mains. They are used also to record the height of the water in tanks, while in mines their use is of the greatest importance for the purpose of recording fan pressures.

A large variety of recording in-



RECORDING GAUGE. SCHAEFFER & BUDENBERG

struments for pressure, temperature and speed—in fact, types for every purpose—are manufactured by the Schaeffer & Budenberg Manufacturing Company, of Brooklyn, N. Y., their gauges being designed for steam, water, air, gas, ammonia, sulphite, for any pressure, or for vacuum.

The greatest care is exercised by this company both in the manufacture and the thorough testing of their gauges, and no instrument is allowed to leave their factory until they are satisfied beyond all doubt that it is properly designed, made, and tested to go into service and do its work perfectly.

A handsomely-printed and illustrated catalogue of forty-seven pages, describing fully their gauges, recording gauges, pressure gauge testing apparatus, recording thermometers, portable test pumps for hydraulic gauges and vacuum gauge test pumps, has just been issued by the Schaeffer & Budenberg Manufacturing Company, who will be glad to send a copy to anyone interested in the subject who may apply for same.

A New Trolley Clamp

THERE has just been placed on the market by the Westinghouse Electric & Manufacturing Company a trolley clamp that embodies several improvements. In this new clamp moisture is kept out and corrosion and wear of threads are prevented by the swivel joint, which permits the boss to be screwed up tight to the stud. The clamping pressure is uniform, as the two side caps are absolutely duplicates. As there are but two countersunk holes in each side, strength is afforded the clamp, making it stronger than the clamping pressure, and, consequently, more permanent. This clamp can be installed with an ordinary screw-driver and monkey-wrench, or with a special type FB combined screw-driver and wrench especially designed for such service, and a few drops of solder in the swivel joint after it is installed adapts it for feeding.

The Science of Waterproofing—No. 3

THE recent Cement Show in Madison Square Garden, New York City, brought to a focus the subject of waterproofing. The entire success of cement construction hinges on the question, "Will the completed structure be dry?" There were only two methods of waterproofing that survived the searching investigations of the engineers, architects and builders who attended the show—first, the asphaltic and tar paper or burlap system installed below grade before commencing the concrete work, and second, the treatment of the surface after construction is completed.

The first method is standardized and well understood by the building profession, its only weak point being that, as long as the structure is stable, the paper and asphalt will remain unchanged; but should any movement of the building take place, through settlement, the paper becomes torn and cannot be repaired.

The water will immediately find its way through the foundations.

The second method is the impregnation of the surface with a paraffin wax compound known by the name of its inventor, Robert M. Caffall, as the "Caffall process."

This process has been used in many cases to repair the damage caused to the asphaltic system by settlement. It is possible to work against a head of water from the interior of a cellar (usually considered an engineering impossibility). An example of this work may be seen in the cellar of the soda pavilion in the New York Zoological Park. In this case there was a "head" of four feet of water, which forced its way through a stone wall of rough ashlar laid up with wide cement joints. The heater cellar of the new Public Comfort Station in the park is another example of working against pressure.

In the treatment of exterior surfaces the asphaltic system has no place. This field is exclusively occupied by the "Caffall process," because of its invisible characteristic. Forced beneath the surface to any desired depth by means of heat, the paraffin becomes incorporated into the body of the structure. The properties of this wax are so extraordinary that the modern drug store *could not exist without it*. What other substances could confine within their bounds such delequent salts and such powerful acids as the modern chemist produces?

Without paraffin these salts would escape out of stoppered bottles, crawl over the shelves, and become liquids by absorbing moisture from the air.

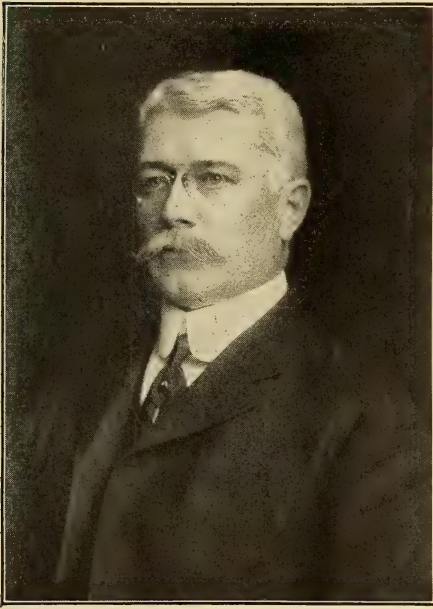
The acids would escape in the same manner, and might form explosive combinations, besides destroying every object not of glass or similar nature.

By means of paraffin all these are brought into subjection and rendered inert until released. Thus, a surface impregnated with this remarkable substance is protected against every kind of chemical action that we call, collectively, "the weather."

PERSONAL

Colonel E. D. Meier, president of the Heine Safety Boiler Company, was elected president of the American Society of Mechanical Engineers at the meeting held in New York, December 6 to 9 last. In the November number of this magazine appeared a portrait of Colonel Meier and a short biographical sketch.

President Meier, due to his long-continued devotion and service to the American Society of Mechanical Engineers and his experience as chairman of its financial committee, as well as a member of numerous other committees, is exceedingly well fitted to assume his duties as president of the society.



WALTER L. PIERCE

The Lidgerwood Manufacturing Company announces the death of Mr. Walter L. Pierce, who has been connected with the firm for thirty-two years, and who has been its secretary and treasurer for the past twenty-nine years. Mr. Pierce died suddenly of heart failure at his winter home, at the Hotel St. Andrew, New York City. His death was wholly unexpected, and was a great shock to his family and asso-

ciates. He had suffered much with nervous troubles, but by devoting much of his time to outdoor pursuits he had apparently recovered, and no apprehensions whatever were felt for him up to the evening preceding his death.

Mr. Pierce was known to a wide circle of personal and business friends. He was remarkable as an organizer, and so perfect was his work that no detail of the great businesses which grew up under his hand was neglected during his long absences from his desk in the search for health. In addition to his connection with the Lidgerwood Company, he was also treasurer of the Hayward Company, and of the Gorton & Lidgerwood Company.

He was a member and director of the Machinery Club of New York, a past-president of the National Metal Trades Association, and an associate member of the American Society of Mechanical Engineers and the Society of Naval Architects and Marine Engineers.

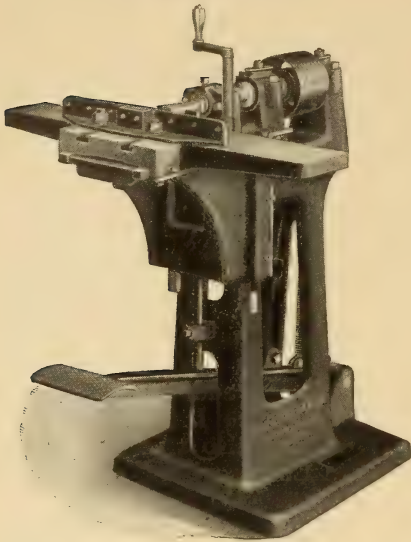
Mr. T. C. Clark, manager of sales of the Sheet Steel Piling Company of the Lackawanna Steel Company, recently sailed for Europe on an important business trip.

Mr. George C. Gordon, for the past four years superintendent for the Wyman & Gordon Company, has accepted the position of works manager for the Park Drop Forge Company, of Cleveland, Ohio.

Mr. D. C. Rose, formerly connected with the Dodge Manufacturing Company, has accepted the position of manager of the new office of the Jeffrey Manufacturing Company at Atlanta, Ga.

Mr. H. B. Dirks, instructor of mechanical engineering at the University of Illinois, has resigned, to accept a position as assistant to the general manager of the National Machinery Company, Chicago, Ill.

A Handy Tool



NO. 270 HORIZONTAL HOLLOW CHISEL MORTISER

WE are pleased to call our readers' attention to a brand-new machine in the way of a horizontal hollow chisel mortiser, manufactured by J. A. Fay & Egan Company, which will be found a valuable tool for the class of work intended. This machine will mortise to a depth of 3 inches, or, by reversing stock, 6 inches. It accommodates chisels from $\frac{1}{4}$ -inch to $\frac{3}{4}$ -inch square.

The frame is a one-piece casting, with good floor support, and is perfectly rigid.

The table is 6 inches wide and 36 inches long. It is moved by foot treadle and raised and lowered by crank. The illustration shows it provided with an adjustable fence.

The chisel mandrel is made of crucible steel and runs in long, self-oiling bearings.

Almost any kind of woodworking plant will find this machine a suitable tool for their purpose.

Woodworkers are invited by the manufacturers to write for their large illustrated circular. Their address is 226-246 West Front street, Cincinnati, Ohio.

The Tenth Annual National Automobile Show at Chicago will be held in the Coliseum and Coliseum Annex, January 28 to February 11, 1911. A special feature of this show will be its Commercial Vehicle Section, which will prove a most comprehensive display of motor trucks, delivery wagons and self-propelled road machines for all sorts of industrial purposes.

Power vehicles suitable for almost every kind of industrial and commercial business will be shown, from tri-car parcel carriers for the quick-delivery service of retailers of light goods to ponderous motor trucks of 5 tons load capacity or more. There will be light and heavy delivery wagons, express wagons, baggage wagons, mail transfer wagons, light and heavy trucks from one ton capacity up, with open platform, stake, slat and covered bodies. Special forms for unusual purposes will be displayed, such as self-propelled chemical and hose carts for fire fighting, trucks with power winches operated by the motor that propels the vehicle for loading and unloading heavy pieces of machinery and boxes, crates and barrels; trucks with self-dumping bodies for handling building materials, ashes, etc.; self-discharging coal trucks; patrol wagons, ambulances, sight-seeing cars and motor stages.

It is expected that this will be the most representative and complete exhibition of the business motor car ever held.

The show will be conducted under the auspices of the National Association of Automobile Manufacturers, Inc.

The three-place table of logarithms printed on celluloid in vest-pocket size, and just issued by the New Britain Machine Company, New Britain, Conn., will prove of use in working out engineering calculations, and is a handy addition to the engineer's card-case. A copy will be sent by them on request.



FINANCIAL NOTES OF THE INDUSTRIAL WORLD

The Jeffrey Manufacturing Company Opens a New Office

In the Fourth National Bank Building, Atlanta, Ga., the Jeffrey Manufacturing Company have just opened a new office, under the management of Mr. D. C. Rose, formerly with the Dodge Manufacturing Company.

The great growth of the business of the Jeffrey Company is indicated by the fact that this makes the tenth branch office they have established in the United States, while they also operate over one hundred agencies situated in the principal cities of the United States, as well as the leading commercial centres throughout the world.

Increase in Exports from the United States to Mexico

Exports from the United States of Mexico are increasing each month, is the report that comes from Mr. Alonzo B. Garrett, U. S. A., Consul at Nuevo Laredo. In September he reports that exports valued at \$1,844,907 passed through his port from the United States to interior points in Mexico, an increase of \$819,497 over the same month in 1909. The indications all show a healthy expansion of trade between the two nations, and that same will continue to grow year by year.

Gains in Gross Earnings of Missouri Pacific Railway

The first annual report of the Missouri Pacific—i. e., of the consolidated company, which includes the numerous lines which formerly went

to make up the Missouri Pacific system, shows gross earnings in 1910, \$53,019,136, and net operating revenue \$15,471,764, the former being an increase of \$6,633,594, and the latter an increase of \$3,012,735. After the payment of charges and rentals the surplus for the year was \$2,759,411, same being an increase of \$1,694,902. After adjustments incidental to the consolidation effected during the year the amount to the credit of profit and loss was \$16,655,587.

The Establishment of New Industrial Enterprises

Mr. Ira H. Shoemaker, industrial agent, of the Delaware & Hudson Company, reports the establishment of many industrial enterprises along the line of their road during the year just ended, while the industrial department of the Missouri Pacific reports that 309 new industries were established during the year in the territory contiguous to the lines of their system. These new establishments represent the investment of nearly \$11,000,000 and give promise of 103,000 carloads of freight annually.

Demand for American Machinery in Italy

Mr. Chapman Coleman, U. S. A. Consul at Rome, Italy, reports that there is a demand in Italy for American machinery, especially agricultural and machine tools and many other of the ingenious mechanical devices in which American invention and manufacture are so prolific.



THE LATEST CATALOGUES

Boiler Feeders or Pressure Pumps

Catalogue No. 83, issued by the Dean Bros. Steam Pump Works, of Indianapolis, Ind., describes fully their special boiler feeders or pressure pumps, and also treats of their Atlantic type of steam pump, which, although designed originally for marine service, in which work it proved more than satisfactory, filling all the requirements of long, hard periods of continuous operation, has, within certain modifications, proved fully as successful and suitable for power plants where high-grade machinery only is desired and where long, continuous service is required. In fact, both for marine and land work their Atlantic type pump has proved eminently satisfactory.

The catalogue is fully descriptive of their many lines of pumps, and contains many tables and much miscellaneous information.

Insulators

The Locke Insulator Manufacturing Company, of Victor, N. Y., have sent us an exceedingly attractive book, treating of their well-known insulators and giving facts concerning their far-extended use.

Woodworking Machinery

J. A. Fay & Egan Company have just issued a new catalogue, No. 84, containing 384 pages, in two colors, profusely illustrated with fine half-tone plates, elegantly bound in a five-color cover. This catalogue is a reduced reproduction of the company's large general catalogue. It will make a valuable addition to any woodworker's or mill man's library, as it shows the very latest models in all

kinds of machinery for working wood. Sent free to any address upon receipt of a request to the manufacturers. Address 226-246 West Front street, Cincinnati, Ohio.

Valves

An attractive illustrated pamphlet has come to hand from Jenkins Brothers, of Chicago, entitled "Jenkins Brothers' Valves: Why They Are Better." An important feature of their valves is that all parts are standardized and are perfectly interchangeable, and every valve made by them is guaranteed by both manufacturer and dealer.

Conveying Machinery

Handsome and fully illustrated catalogues are received from the Link-Belt Company describing their retail coal pockets, conveying machinery for sugar estates and refineries, conveyors for freight and packages, their peck carriers, and also a general catalogue of 400 pages descriptive of their full line of conveyors and conveying machinery. These books will be found of service to all who have to do with conveying problems of any nature, and copies can be obtained by addressing them at either Chicago or Philadelphia.

Concrete

"Things Worth Knowing About Concrete." Under this title the Vulcanite Portland Cement Company, Land Title Building, Philadelphia, is issuing a series of little leaflets that will prove of value and interest to users of concrete.

LATEST CATALOGUES

Graphite Products for the Railroads

A new booklet has just been issued by the Joseph Dixon Crucible Company, of Jersey City, N. J., under the above title. This, as its name implies, covers the Dixon line of products that are widely used in railroad service.

The object of the book is to bring under one cover all the various products in the Dixon line that are of interest to the various mechanical departments of railroads. These include various graphite lubricants, protective paint, crucibles, facings, etc., all of which have been found by actual service to give satisfactory results.

The booklet consists of 40 pages, and is quite attractively illustrated by means of photographs showing different views of railroad stations and yards, different types of locomotives, stretches of track, signals, bridges, etc.

A copy will be sent free on request.

Electricity

The General Electric Company, Schenectady, N. Y., has recently issued the following bulletins, and will send copies to those interested on request:

"Automatic Voltage Regulators for Direct Current Generators";

"Direct Current Exciter Panels";

"Signals, Auxiliary Apparatus and Materials."

The same company has issued a handsome edition of the paper read before the National Electric Light Association on the subject of "Street Illumination." This pamphlet compares the results obtained from the use of luminous and flame arcs with those resulting from the use of open and enclosed carbon arcs. The subject is treated from the standpoint of the illuminating engineer and is discussed in detail.

This pamphlet, No. B—3,006, contains half-tone illustrations showing street illumination by luminous arcs in various cities. There are also nu-

merous diagrams. The subject is treated exhaustively, and should be of great interest and assistance to all interested in this branch of engineering.

Recording Gauges

The Bristol Company, of Waterbury, Conn., reports that more than 20,000 Bristol's recording gauges have been sold. This company has just issued Bulletin No. 140, descriptive of their well-known gauges for pressure and vacuum, and it will be glad to send a copy on request.

Friction Clutches

The Carlyle Johnson Machine Company, Manchester, Conn. Catalogue "E," 1911, 35 pages, 4½ inches by 7 inches. An issue of 25,000. The catalogue is enclosed in a handsome cover of two-toned blue, with a clutch cut and company monogram embossed thereon, and is filled with attractive illustrations showing the Johnson clutch, factory views, etc. The inside pages have an attractive blue border to correspond with the blue cover, this border being made up of reduced cuts of Johnson friction clutches, with the headings at the top of the company name and address, as always used in their trade paper advertising.

This catalogue is larger and more complete than previous ones, and deals almost exclusively with the driving of machinery through friction clutches, special attention being paid to the driving of machinery from line shafting, thus eliminating cross-belted, countershafting, etc. There is special mention made of clutches for cut-off coupling work for use in connection with marine motors, as a one-way clutch for which work this type of clutch is particularly adapted. The lists are very complete, extending to clutch parts, which are numbered to correspond to the numbers indicating the parts on sectional views. Copies will be sent free to interested parties.

The Economics of Engineering

THERE have been various definitions of engineering, most of them derived from some especial point of view; but one of the broadest is that which defines the engineer as the man who can do for one dollar what anybody else can perform for two dollars. From this viewpoint the engineer is justly entitled to be considered as an economist, and it is a matter of general acceptance that the engineer is to-day entering more and more into the successful conduct of great business enterprises.

It is well understood that the cost of most engineering operations is affected largely by the labour expense and by the overhead charges. The labour costs are continually increasing, so far as individual wages are concerned, and can be kept down in the aggregate only by using as few men as possible and by employing mechanical appliances to the greatest practicable extent in the place of human effort. Overhead charges are incurred, in nearly all cases, upon a time basis, and hence the use of such machinery as will reduce the amount of time required for any job will reduce its proportional share of fixed cost. There is thus a double incentive to install mechanical appliances to replace human labour, since the actual operative cost of the work is reduced, and the speed is so accelerated as to diminish the otherwise preponderating overhead load.

It is in the central power station that a marked opportunity presents itself to effect a distinct improvement over the old methods in these respects. There is probably no more laborious and burdensome kind of work than that of shoveling coal, unless, perhaps, it is the removal of ashes. Every steam power plant necessarily involves both operations, and in each installation of this kind there is opportunity to dispense with a large proportion of muscular effort and replace it with power machinery.

If, however, this replacement is to

be effected to the best advantage, the installation should be designed with proper respect to the latest methods. The experience of engineers who have devoted attention to this particular department of work enables many economies to be effected.

It has well been said that the hauling of coal is actually a problem in the transmission of power, and it is certain that there is no more highly charged storage battery than a lump of carbon. In the transmission of power in the form of the electric current every precaution is taken to secure the uninterrupted flow, and, in like manner, there should be corresponding care taken with the movement of energy represented in coal. To haul it smoothly and swiftly for hundreds of miles over a railway, only to dump it into a heap to be tossed about by ill-handled shovels, is a notable breach of continuity. Far more rational and efficient is the system which receives the fuel from the railroad car to the bucket conveyor and delivers it to the storage bin, from which it flows to the furnace, to be consumed, so far as its combustible elements are concerned, and to be continuously removed, so far as the unburnable portions require. When such a system is scientifically installed, we see a distinct example of the work of the engineer as an economist, reducing the number of ineffective operations, and, at the same time, increasing the efficiency of those which are retained.

Apart from the desirability of reducing the labour cost by dispensing with a large portion of the human effort, there is also the important feature which always follows the replacement of men by machines—the minimizing of the probability of labour difficulties. With the machine there are included only the details of mechanical construction and operation, leaving out of consideration almost wholly those intricate and difficult problems which necessarily accompany the management of numbers of partially responsible men.

Fuel Handling Economics

The diagram shows a unique arrangement of the coal and ashes handling machinery at the Power Station of the Edison Electric Company, Delray, Mich. The installation is located in the tower of

and the design of the machinery has effected a great saving of ground space.



Economical use of time and labor

Our specialty is the economical handling of coal and ashes in Power Stations, and our engineers are ready to study your particular case and apply the cheapest and most modern methods. They are at the service of any present or prospective customer. Call on them to solve your problem.

Hunt Noiseless Bucket Conveyor
Hoisting and Conveying Machinery
Industrial Railways

Steam Shovels

Electric Locomotives
Cable Railways
Automatic Railways

C. W. Hunt Co., West New Brighton, N. Y.

N. Y. City Office, 45 Broadway

ATLANTA, GA., 607 Rhodes Building
 RICHMOND, VA., State Bank Building

CHICAGO, 1616 Fisher Building
 SAN FRANCISCO, 865 Monadnock Building

Earning the Cost

WHEN a man is employed for wages his time is kept and his work inspected, and if it is found that he does not return to his employer full value for the pay which he is receiving he is dropped as an unprofitable employee. Manufacturers are now beginning to consider their mechanical appliances in a similar light and to compare the earning value of a tool or other appliance with the first cost and the subsequent charges which it involves.

There are various ways of ascertaining how profitable or how costly a machine really is, these being dependent to a large extent upon the nature and use of the tool itself. A machine tool in the shop, under good management, is kept busy for a large proportion of the time, and it is usually practicable to fix for it an hourly rate to be charged to the different jobs upon which it is used, this charge being additional to the cost charge for the operator.

There are some machines, however, with which it is hardly practicable to make such a methodical accounting. They are used in such an intermittent manner that an intelligent time rate is difficult to establish; their work is not directly productive, and their results cannot be positively distributed. In such a class may be placed the great family of devices for handling merchandise, for moving work in and out of the shop, and for doing things formerly requiring the effort of the old-time labouring gang.

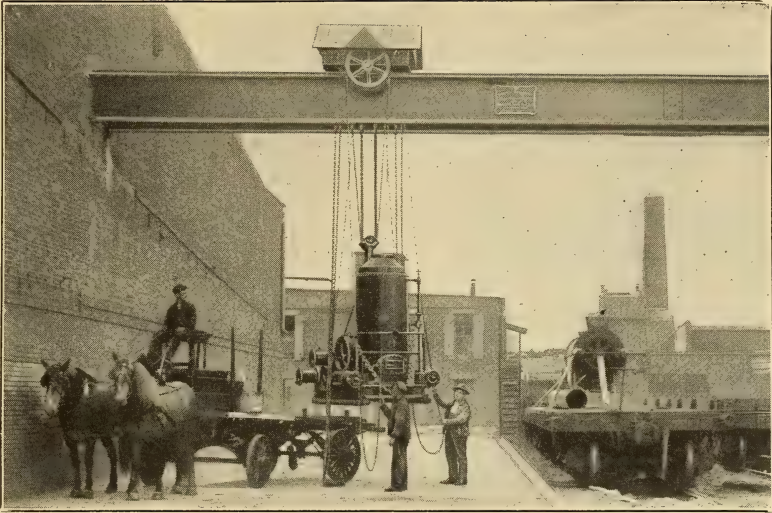
At the same time, it is fully recognized that such appliances, when properly designed and constructed and intelligently used, constitute some of the best earning machines in the establishment, and as such they should be credited with the money which they make, or rather, with the losses which they prevent.

For devices of this kind, for the power traveling crane, the shop railway, and, above all, for the invaluable chain hoist and overhead tram-

rail, it has been found that a most definite way of determining whether the apparatus is earning its cost and making money for its owner is to compare what it does with what it would cost to do it in the old way.

The chain block, for example, is designed to lift and transport burdens, and if it does this work efficiently it is also lifting another kind of burden—a portion of the expense burden which must be borne by every manufacturing establishment. It does this part of its work by relieving the expense account of the wage charge of the men who would otherwise be required to lift and move the merchandise or other load; and when a chain block is installed in workshop, warehouse or dock it is entirely possible to determine just how many men it replaces and what their services have been costing. There is here a direct and positive way of determining the earnings of the appliance in the form of cash saving, and, when such a comparison is made, the time in which the machine will not only earn wages, but also wipe out its first cost, will surprise its fortunate possessor.

There is, however, another method in which such an appliance as a tramrail and chain hoist conveyor system will earn its cost many times over, and that is in the indirect savings effected by the reduction in delays to other operations, in the acceleration of the work of expensive men and tools which it serves, and in the general influence which it exerts in raising the efficiency of the entire department. It is impracticable to compute the cash value of such economies, but it is sometimes possible to observe how things are delayed if, for any reason, the hoist is out of service. Generally, it will be found that the indirect gains are much greater than those which can be immediately reckoned, and, when taken together, the direct and indirect returns render a high-class hoist one of the most profitable investments which can be installed.



A twenty ton Triplex Block suspended from a crane trolley and mounted on a fifty foot span runway and used for loading and unloading cars in the yards of the New York Dock Co., Brooklyn.

These Are Facts

THE Triplex Block shown in the picture above paid for itself four months after installation in the saving of time and labor.

This is a pretty good record, but nothing unusual for a Triplex Block.

An installation of this character is the quickest, simplest, safest and cheapest method of handling materials the world has ever seen.

Triplex Blocks { 16 Sizes: One-quarter ton to forty tons.
300 Active Stocks all over the United States.

The Book of Hoists tells much—for a postcard

The Yale & Towne Mfg. Co.

Makers of Yale Products

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In writing to advertisers, please mention CASSIER'S MAGAZINE.

Conservation

WE hear much nowadays about the conservation of various kinds of resources, and yet the term "conservation" appears to have so many different meanings that it is not always easy to be sure just what is meant in any particular case. There is one subject, however, in which there is no probability of a misunderstanding, and that is the desirability of effecting a reduction of losses by the reduction of wastes.

In many manufacturing establishments the whole science of success depends upon the extent to which the expense account is kept down to the minimum point. The product may be a staple article, sold at a market price which the manufacturer cannot control. The material must be bought in the open market, and the current rate of wages paid to employees, and hence the only point which can affect the greater profit of one such manufacturer over another, lies in the extent to which unnecessary wastes are avoided and maximum efficiency secured in all operative departments. It is an important part of the work of the engineer to aid in the reduction of wastes and losses and to enable the highest possible efficiencies to be secured. In this respect the engineer should be regarded as one of the great benefactors of mankind. The steam engine, which formerly required five or six pounds of coal to produce a horse-power, now demands only two pounds, and its competitor, the modern internal-combustion engine, can get along very well with only one pound. The machine tool, which originally ran at a slow speed and turned out work which required much hand fitting for its completion, now runs at much higher speeds, produces far greater results, and furnishes a product which is ready for use without requiring a touch from file or chisel. These are but isolated examples of the manner in which the engineer has enabled the manufacturer to turn a losing business into a

profitable one, but they will serve as illustrations.

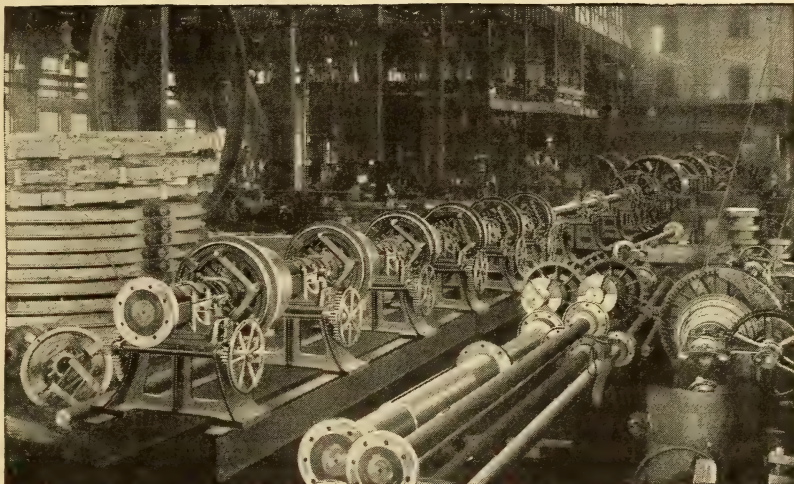
When it is desired to reduce waste in order to cut down losses, it is always wise to make an investigation and determine just where the biggest losses are, and hence where the best opportunities for saving exist. In very many shops there will be found abundant opportunity for reduction of waste in the machinery of transmission of power. The actual proportion of the motive power required for operating the machinery of transmission is sometimes greater than that which is actually applied in performing useful work. Indicator tests of steam engines, made with full load and with transmission machinery, will frequently show as much as 40 per cent. of the power consumed in the latter task, while in other and better arranged and equipped works this transmission consumption of power will be as low as 25 per cent. Here, then, is a fertile territory for the engineer to cut down losses and help make profits for the owner of the establishment.

The interesting part of such an undertaking lies in the fact that the methods for reducing such transmission losses are perfectly well known, and are open to everybody, without requiring any expert advice other than that which can be obtained in the open field. All that is necessary is to use shafting which is straight and true, and of correct proportions; to place upon it pulleys which are light, true, and well balanced, and which carry belting or rope transmission of ample capacity for the work. The shafting should be put truly in line and kept in line by the use of hangers which are stiff, strong and well placed; carrying bearings of ample proportions, continuously lubricated, and self-adjusting to varying stresses and movements.

The whole job, in short, should be entrusted to specialists, not only in the design of power transmission machinery, but in its manufacture, erection, and adjustment.

DODGE

The Factory Power Transmission System Should be a Complete Unit—Properly Designed and Tested



Outfit of Shafting, Dodge Friction Clutches, Bearings and Pulleys under running test on our assembling floor

NO satisfactory service would be expected from an engine if the frame was bought here, the cylinder there, the piston and other parts picked up elsewhere, and assembled on the ground.

¶ And the outfit which transmits, is as important as the engine that generates the power.

¶ Complete equipments of Dodge Transmission Machinery represent the greatest possible efficiency. Our engineers design Dodge outfits for the particular service which they are to perform.

¶ And, in addition, every special equipment is assembled and put under a running test in our shops. No less a try-out will demonstrate the absolute accuracy of all the parts of the outfit.

¶ Please consider what this kind of tested, established efficiency means in economy of quick erection—how it eliminates friction loss in operation and reduces the expense of renewals and attendance.

¶ If you contemplate the installation of power transmission machinery, or if your present power distribution system is uneconomical, write us. We can help you secure efficiency.

¶ Send for our new complete general catalog CC-10, "Power Transmission Engineering," and other information on this subject.

DODGE MANUFACTURING COMPANY

STATION A-11, MISHAWAKA, INDIANA

New York
Pittsburg

Chicago
Boston

Philadelphia
Cincinnati

Minneapolis
Brooklyn

Atlanta
St. Louis

Agencies in the Other Principal Cities of the Country

Air Compressor Development

IT has often been remarked that those most intimately responsible for the designing of apparatus and the installation and operation of plants for compressed air practice have been neglectful as to the efficiencies, so that, up to very recently, compressed air has been discredited, and its adoption in many cases has been delayed by the prevalent existence of unnecessarily wasteful conditions which have operated as deterrent examples. In recent years there has been an encouraging change for the better in this particular, so that now it may be said that much of the air used is compressed at one-third of the power-cost as compared with the power-cost of only a score of years ago, with commensurate savings also in labour and other items.

We may gather what consolation we can from the fact that steam economy has advanced even more slowly than this. From the *Great Eastern* to the *Campania* there was an interval of forty years, the former having 8,000 horse-power and the latter 30,000 horse-power, upon practically the same gross coal consumption. In the successive trans-Atlantic steamers which came out in the meantime each represented at the time the best skill and judgment of its designers, but the same can hardly be said of air compressors. The standard compressor, and practically the only compressor offered by the leading builders less than a score of years ago, had a single steam cylinder and a single air cylinder, thus ignoring the well-known possibilities of economy at both ends, or in respect to both functions of the machine.

The attention of the engineering world was at this very time being especially directed to the possibilities of steam economy by the various reports of tests of pumping engines in the Transactions of the American Society of Mechanical Engineers and elsewhere, so that there would seem

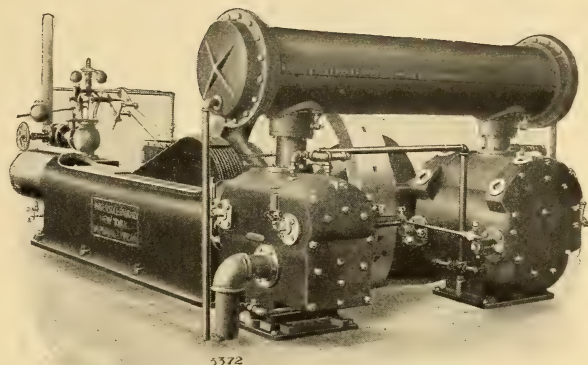
to have been special suggestion and incentive to consider and adopt similar economies in compressed-air practice.

The water-pumping problem, however, is a vastly simpler one than that of air compression; indeed, there would seem to be no simpler proposition for the steam engineer than the high-duty pumps, while that of the air compressor is among the most complex and difficult. In the pumping engine the work is continuous, and the machine may run day and night, without even a governor and without change of adjustment. The resistance against the piston is constant for the entire stroke, and there is no such thing, even, as clearance to be thought of.

In the air compressor the work is never continuous at a uniform rate, because the air can be stored only in comparatively small volumes and the rate of consumption is always varying. In the cylinder a continually increasing resistance opposes a continually diminishing steam pressure. Clearance cannot all be eliminated, and whatever there is represents reduced capacity. The heating of the air during compression necessitates the cooling of the interior surfaces to secure safe lubrication, and the keeping the air as cool as possible is a necessary expedient in the saving of power. While water may be pumped to any pressure in a single cylinder, air must be compressed in stages, with efficient cooling between them.

The complete, self-contained and up-to-date machine, which embodies all which is best in capacity, efficiency, economy and reliability, is not the cheapest to build nor the machine easiest to sell to the uninformed; but now customers are being educated, and especially the best engineers are becoming alert and are seizing their opportunities, and large, permanent plants, embodying all that skill can design and capital demand, are becoming far more frequent than formerly.

"IMPERIAL" DUPLEX AIR COMPRESSORS



**"The
Compressor
with an
Individuality."**

A glance at an "Imperial" Compressor, or at its picture reveals the distinctive design which differentiates it from every other type.

Sturdy strength and rugged simplicity are emphasized in every one of its lines; and investigation of its construction only reveals other superiorities which do not appear on the surface.

Note some of the distinctive "Imperial" features:— enclosed, dust-proof construction; flood lubrication— a unit structure, one main frame uniting and supporting all parts; maximum capacity with minimum floor space; immediate access to every part; all the self-contained quality of the plainest straight line type; a unique simplicity; "Imperial-Corliss" inlet and "Imperial Direct Lift" discharge valves.

Within its range of capacities there is no better compressor made than the "Imperial X" Meyer steam driven and the "Imperial XB" power driven.

Many existing compressor types are patterned after the "Imperial." But a comparison of design, materials and workmanship reveals the fact that there is, after all, only one "Imperial"—the original.

INGERSOLL-RAND CO.

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The Development of the Lathe

IN studying the development of any modern machine tool from the first crude beginnings, it is interesting to observe that two important principles have made themselves felt. The first, and usually the more obvious one, was the endeavour to do by a machine that which was either impossible to unaided human effort or else so difficult as to be impracticable. The second feature, following upon the more or less successful achievement of the first, was to produce a far greater output than any man could accomplish by himself.

When the primitive man hit upon the idea of making his work revolve, and holding the tool against it, he found that he could produce round work in far more perfect shape and character than by the unaided effort of hand tool; this invention is lost in prehistoric obscurity, but it probably began with the first crude potter's wheel, with a vertical spindle, kicked around by the foot of the operator. In this machine the tool was, and often yet is, the hand of the workman. Simple as it was, this lathe did better work, and more of it, than was heretofore possible; and from this elementary beginning has grown the great family of rotating machines, which includes the engine lathe, the boring mill and the automatic machine in all its variations.

It is only in late years that the variable influence of the hand of the operator as a tool holder has been eliminated. In the early part of the last century the efforts of Maudslay, Nasmyth, Bodmer, Clement and others resulted in the development of the slide rest, while in recent years, and primarily in the United States, there has been produced a method of holding a number of tools in a table arranged to be revolved on a vertical axis, presenting different tools according to a predetermined sequence, and enabling repetition work to be executed automatically in a manner far superior to the older methods, while, at the same time, greatly in-

creasing the output of the machine.

In the modern lathe it is well understood that the production is limited only by the cutting tools, and that the driving gear must permit the delivery of the maximum amount of power necessary for this purpose, and that the weight and proportions of the machine must furnish ample stability and rigidity under such conditions. In addition to ample stability, the gear-changing mechanism should be so designed as to permit the clutches to be operated without such violent action as to injure the gearing. The turntable which carries the cutting tools must itself be rigidly mounted upon a cross-slide, supported so firmly as to include the stability so essential to the whole, and, at the same time, permit the movements required for the operations, while the system of longitudinal and transverse stops and indexing mechanism must regulate the extent of these movements with accuracy and precision.

When a machine of this type is so designed as to permit the attachment of a wide variety of special tools and fixtures, it practically becomes a special tool without the defect of limited applicability. It is, therefore, capable of varied service, the only changes demanded for a change in product being the necessary modifications in the tools themselves.

Thus it is seen that the course of mechanical evolution by which the crude potter's wheel has been developed into the modern turntable lathe is a natural progression, using the rotating spindle, with ample power and control, for the movement of the work, and another vertical spindle, combined with a vastly improved carriage and support, to receive the tools. The sequence of operations thus made possible, and controlled positively and accurately by mechanical action, enables repetitive work of the highest accuracy to be produced in great quantity, independently of the judgment or manual skill of the operator, a result essential in these days of commercial scientific manufacturing.



FINANCIAL NOTES OF THE INDUSTRIAL WORLD

Cruiser to Cost \$1,000,000 to be Built for China by the New York Shipbuilding Company of Camden, N. J.

A contract has recently been received by the New York Shipbuilding Company from the Chinese Government for the construction of a cruiser of some 2,600 tons, which will cost more than \$1,000,000. The armour and guns for her will be furnished by the Bethlehem Steel Company. This will be the first warship ever built in this country for the Chinese, and the contract came as the direct result of the visit to this country last summer of Prince Tsai Hsun, the uncle of the infant Emperor of China and head of the re-organized Chinese Navy.

Oil Production of the United States for 1910 Two-thirds of World's Supply

The year 1910 proved eventful in the development of new oil supply in the United States, and fully sustained the wonderful production of the three past years.

The increased production, which came to between 200,000,000 and 204,000,000 barrels, was more than the whole world produced seven years ago, and represents two-thirds of the world's supply.

California, owing to the remarkable developments during the year in the Sunset-Midway district, leads, with 73,000,000 barrels; the Mid-Continent and Rocky Mountain fields follow, with 53,000,000, while Illinois and the Appalachian and Lima-Indiana fields follow, with 32,000,000 each, and the Gulf and Caddo fields furnished 14,000,000.

A Large Foundation Contract

The MacArthur Concrete Pile and Foundation Company has recently been awarded the contract for the pile foundations of the large retaining wall to be constructed for the new passenger station of the Oregon & Washington Railroad at Seattle, Wash. This retaining wall will be of reinforced concrete, from 32 to 50 feet high and about 1600 feet in length, and will replace the wooden construction now in use. The foundations will consist of 1969 piles of the Pedestal concrete type, each pile averaging about 40 feet in length, with a stem or column 17 inches in diameter and a base or pedestal 36 inches in diameter. Including this work, which is the largest of its kind ever awarded in the Northwest, the MacArthur Concrete Pile & Foundation Company has now under contract over 100,000 feet of Pedestal piling.

Vonnegut Machinery Company

The Vonnegut Hardware Company, Indianapolis, Ind., separated their machinery department from the rest of their business January 1, 1911, and will operate same under the name of the Vonnegut Machinery Company as a branch of the Vonnegut Hardware Company. The Vonnegut Machinery Company will be located in the building formerly occupied by the Francke Hardware Company, 43 to 45 South Meridian street. The sales organization will include Messrs. Anton Vonnegut, Charles Rassman and C. B. Williamson.

CASSIER'S MAGAZINE

Hydraulic Machinery in Italy

There has been authorized by the Ministry of Public Works the expenditure of about \$70,000 for hydraulic works in the Provinces of Bari, Naples, Lucca, Venice, Ferrara, Forli, Milan, Belluno and Ravenna, Italy. It would seem that this should afford American builders of hydraulic machinery an opportunity, and they should communicate with the Ministero dei Lavori Pubblici, at Rome.

A Manufacturer's Library

There has been recently opened by the Commercial Bureau Company, in the Hudson Terminal Building, 50 Church street, New York, a manufacturers' library.

This is a national movement to centralize, in a free reference library in the city of New York, the trade literature of the manufacturing interests of the United States.

The use of the library is free to all visitors who may desire to consult the literature on file. An invitation is also extended to out-of-town visitors to make the library their headquarters while in New York.

Other features of this movement consist of a number of finely appointed private rooms provided for the free use of manufacturers or buyers; private desks which may be obtained free for temporary use or reserved at a nominal charge for a longer period; special facilities for the receipt and safe delivery of all mail or telegrams sent in care of the library; private sound-proof telephone booths, with service provided at actual company rates. The services of competent stenographers and typewriter operators may also be had at a nominal charge for the actual time occupied.

The American Foundrymen's Association will hold their convention at Pittsburg, Pa., May 23-26, 1911. Dr. Richard Moldenke, Watchung, N. J., is the secretary.

Recreation of Employees

In keeping with its progress in welfare work, the Dodge Manufacturing Company has just opened to employees of the big plant at Mishawaka, Ind., an athletic field fully equipped for tennis, croquet, quoits, bowling on the green, etc.

As an honor to Melville W. Mix, president of the company, and father of the proposition, the field has been named after him by the Dodge Club, under whose direction it will be conducted.

The ground is located near the factory buildings and in a section of the city easily reached by Dodge men. The place is enclosed by a woven wire fence, by which its benefits can be exclusively enjoyed by the parties directly interested.

Surrounding the field is a system of Tungsten drop lights, affording facilities for indulging in the various sports after dark. Under shade trees comfortable lounging seats have been placed as a resting place for players and for the use of lookers-on.

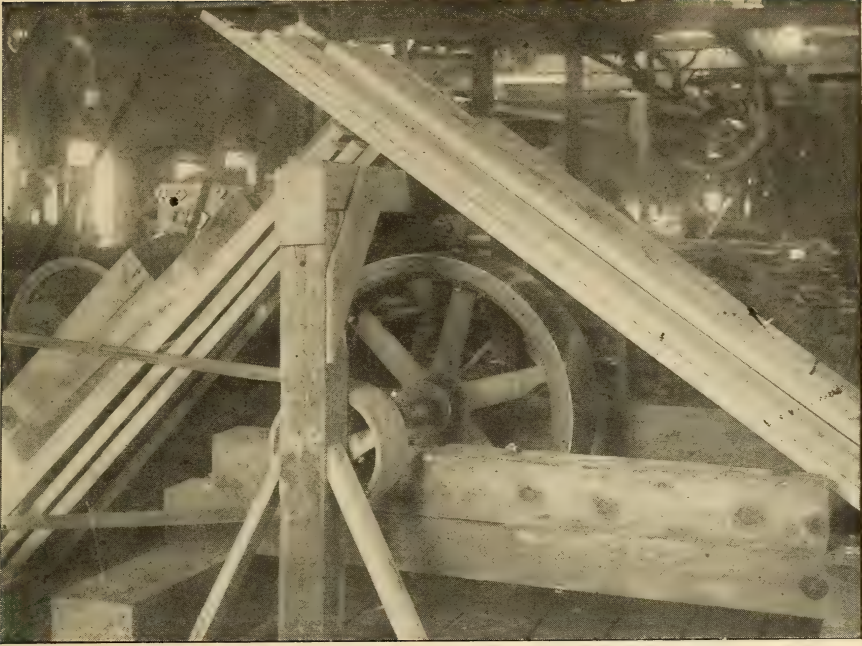
Technical Illustrating

The Michel-Kurze Company, with offices in the Hudson Terminal Buildings, New York, has just been organized to do photo retouching and illustrating of machinery subjects.

The business will be managed by A. Eugene Michel, Assoc. Mem. Am. Soc. M. E., and the staff of artists will be in charge of Wm. F. Kurze, who was art director of the Scientific Engraving Company during the past four years, and is one of New York's best-known artists in mechanical lines. The extensive engineering and advertising experience of both members qualifies this firm to deliver high-grade work to manufacturers of machine tools, steam and electric power-plant apparatus, and other engineering products.

Arthur D. Little, Inc., 93 Broad street, Boston, Mass., have been appointed chemists for the American Brass Founders' Association.

MANUFACTURING NEWS



PULLEY ARRANGED FOR HIGH-SPEED TEST. DODGE MANUFACTURING COMPANY

The Bursting Strength of Pulleys

It is well known that the limit of speed to which a wheel may be revolved depends upon the relation of the stresses due to centrifugal action and the tensile strength of the material. Various theoretical discussions have been made at different times, but there are so many unknown elements in the problem that engineers have felt safer in depending upon data derived from experimental investigations.

It has generally been assumed that a speed of about a mile a minute at the rim is the safe limit for cast-iron pulleys and flywheels, and most engineers endeavor to keep speeds below these figures. Band-saw mills, with wheels made of wrought iron or steel, are run at speeds as high as 7,500 feet per minute with safety; but above these speeds the risk has generally been considered too great to be incurred in regular service.

At the convention of the American Society of Mechanical Engineers in 1904 there was presented a paper by Professor Charles H. Benjamin de-

scribing experiments made upon several flywheels about 4 feet in diameter, these being tested to destruction, under conditions which permitted the bursting speeds to be accurately determined. The details of these tests may be found in the Transactions of the Society, but it may be noted here that a cast-iron pulley *burst* at a speed of 1,100 revolutions per minute, corresponding to a rim velocity of 13,800 feet per minute, or about $2\frac{1}{2}$ miles.

A speed of a mile per minute with such a pulley would, therefore, have given a factor of safety of only about two and one-half. Another cast-iron pulley, of the split type, burst at 7,500 feet per minute rim speed, while an elaborately built-up wheel, with arms and braces of phosphor-bronze and rim of cast steel, burst at a speed of 1,775 revolutions, or 22,300 feet per minute rim speed—about $4\frac{1}{4}$ miles per minute.

In comparison with these recorded tests by an eminent scientific authority, it is of especial interest to compare data recently obtained by

the Dodge Manufacturing Company in connection with tests of a pulley of their standard make having a wood rim and cast-iron spider. The pulley tested was 46½ inches in diameter, and thus sufficiently close in dimensions to those tested by Professor Benjamin to make the results comparable. A pulley of this type and size had been ordered by a customer under the condition that it should be safely operated at a rim speed of 9,000 feet per minute.

In order to make tests of the limiting speeds of such pulleys, the Dodge Manufacturing Company made two pulleys at the same time, the rims of both being made from the same lot of lumber and the spiders cast from the same ladle; every care was taken to make the two pulleys as nearly alike as possible. The pulley for the customer was tested to a rim speed exceeding 10,000 feet per minute and delivered. The companion pulley was then speeded up until a rim velocity of 29,200 feet per minute was attained!

That is to say, the velocity at the rim of this Dodge pulley exceeded 5½ miles a minute. So far from bursting at this speed, the pulley appeared to have experienced no perceptible weakening, and, as no higher speed was attainable with the apparatus used, it was impracticable to discover what the bursting speed really was. When to the well-known advantages of the Dodge wood-rim pulleys we add this demonstrated resistance to bursting at high speeds, it will be seen how superior they are in all respects to pulleys of the older type, whether solid or built-up.

Practical Information

ONE of the great difficulties which is encountered by every investigator and instructor appears in the rapid rate at which practical information outstrips not only the text-books, but also the current technical literature of a subject.

It is true that there are certain

fundamental facts which have a sort of permanency, but even in such cases the point of view is continually being changed, so that the information acquired a few years ago and embodied in the text-books and works of reference of to-day is not always up to date.

If this is true of the more established subjects of scientific work, it is still more the case with the latest developments of applied science. The work which has the greatest practical value is being done, not in the research departments of the technical schools, but rather in the testing rooms and laboratories of the industrial establishments of the country.

It follows that the latest and most reliable information in many of the more recent practical and scientific lines of work appears, not in the text-books and reference works, but in the numerous trade catalogues and pamphlets of instruction issued by the manufacturers themselves. The engineer knows that, when he sees the data and results of tests given in the current publications of eminent firms, he has before him the very latest word upon the subject—the reliable work of competent specialists.

An excellent example of these facts appears in the case of the article upon Vanadium Steel, by Mr. W. E. Gibbs, which appeared in the issue of this magazine for June, 1910. The information contained in that article in connection with the properties of the vanadium alloy-steels, and the results of tests under various stresses, were those furnished by the American Vanadium Company, of Pittsburgh, Pa., the tables and data given in the article of Mr. Gibbs and in the trade literature freely given out by the American Vanadium Company being practically identical, and due to the experimental researches made in the laboratory of the latter company. The publications of this company form excellent examples of the fact stated above as to the manner in which trade literature keeps ahead of the text-books.

MANUFACTURING NEWS

Obituary

CHARLES HILL MORGAN

Charles Hill Morgan, past president of the American Society of Mechanical Engineers, and eminent for his share in the development of the iron and steel industry, died at his home in Worcester, Mass., on January 10, 1911.

Mr. Morgan was born in Rochester, N. Y., in 1831, and began his mechanical career as a boy of twelve years old in a mill at Clinton, Mass., and by his ability and ingenuity as an inventor he rapidly attained eminence in the design and manufacture of steel-working machinery.

Probably his most important contributions to the industry are found in the development of the continuous rolling mill and in the application of gas fuel to metallurgical operations. As long ago as 1869 Mr. Morgan superintended the erection of the first continuous rolling mill in the United States, this being at the works of Messrs. Washburn & Moen, of which Mr. Morgan was superintendent. This mill was built from the designs of the inventor, Mr. George Bedson, of Manchester, England, and it was followed by others of greatly improved design invented by Mr. Morgan himself.

Mills of the type designed by Mr. Morgan enabled the rolling of a 6,000-pound ingot with the initial heat of the converter directly and continuously into a bar $1\frac{1}{2}$ inches square and 800 feet long, and the same principle is applied to miscellaneous rolling, including hoop and cotton tie. By his improvements in the gas producer and in the gas heating furnace Mr. Morgan also added greatly to the productive capacity of the modern rolling mill.

Mr. Morgan did much to bring before the engineering profession the pioneer work of Henry Cort in the invention of the rolling mill, and effected the erection of a monument to his memory.

The visit of the American Society of Mechanical Engineers to Europe

in 1900 occurred during Mr. Morgan's term as president of the society, and those who formed that party will remember the rare grace and dignity with which he filled the office at the various important professional and social functions of that notable season, both in England and on the Continent, occasions which included presentations to Queen Victoria of England, King Oscar of Sweden and King Leopold of Belgium.

At the time of his death Mr. Morgan was president of the Morgan Construction Company and the Morgan Spring Company, both of Worcester, Mass., and also first vice-president and director of the American Steel & Wire Company, of Cleveland, Ohio. He was always interested in practical technical education, and was one of the founders and for many years a director of the Worcester Polytechnic Institute.

GUSTAVUS C. HENNING

Gustavus Charles Henning, well known in mechanical engineering circles on both sides of the Atlantic, died in New York on December 30, 1910.

Mr. Henning was born in Brooklyn, N. Y., in 1855, and received his technical training at the Brooklyn Polytechnic Institute and at the Stevens Institute at Hoboken. His early engineering work was upon railway and machine shop construction and on inspection work in connection with the construction of the Brooklyn Bridge, and from this to his special department—the testing of materials of construction—became a natural progression.

Since 1883 he practiced as consulting engineer in New York City, giving especial attention to the scientific testing of materials, in which subject he attained eminence, and in connection with which he developed improved methods and apparatus. He visited Europe in 1887-1889 in connection with the development of the Emery testing machine, and also represented the American Society of

CASSIER'S MAGAZINE

Mechanical Engineers as its delegate at conferences of the International Society for Testing Materials, at Vienna (1893), Zürich (1895), and Stockholm (1897), where he was chosen honorary president during the conference and chairman of the section on metals, and at Dresden (1898), where he was elected member of council.

Mr. Henning translated into English the important "Handbook of Testing Materials for the Constructor" of Professor Adolf Martens, director of the Royal Testing Laboratory, at Charlottenburg, Berlin, and contributed numerous papers to the proceedings of professional societies and to the technical press.

WILLIAM H. BRYAN

William Henry Bryan, an active and well-known member of the American Society of Mechanical Engineers, died in Chicago on December 5, 1910. He was born at Washington, Mo., in 1859, and received his education at Washington University, St. Louis, where he practiced engineering subsequently with success, being especially interested in the design and installation of power plants in business buildings. At the time of his death he had just been appointed engineer for the School Board of Chicago, an important post, for which he had passed a competitive examination with marked ability. Mr. Bryan was past-president of the Engineers' Club of St. Louis, and had been especially active in furthering the work of the American Society of Mechanical Engineers in that city.

JOHN R. MAXWELL

Mr. John Rogers Maxwell, for many years president of the Atlas Portland Cement Company and a director of Manning, Maxwell & Moore, Inc., and also prominent in railway circles, died at his home in Brooklyn, New York, on the 12th of December, from cerebral apoplexy.

Scientific Management

IN a review of business conditions during the past year and a discussion of the prospects for 1911, Hon. Melville W. Mix, president of the Dodge Manufacturing Company and president of the Indiana Manufacturers' Bureau, shows how the progressive manufacturer appreciates the influence of good management upon business prosperity.

Referring especially to conditions in Indiana, Mr. Mix says: "Many of us, inclined, at high or low tide, to keep things moving, have added to our records in producing goods, in selling them at a profit, and in improving our facilities, the tendency now being to take advantage of productive economies in manufacturing, rather than to reach extraordinary volume."

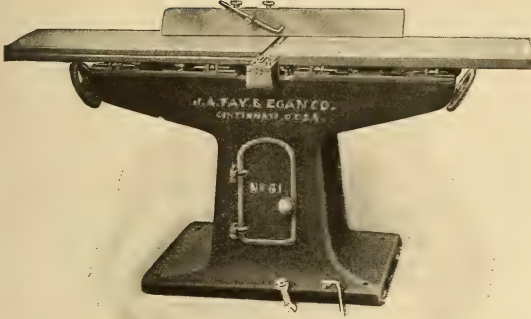
Mr. Mix calls attention to an interesting point—that the official figures for the past year show that the commerce of the entire world exceeded that for 1909 by 9 per cent., and that the United States doubtless contributed more than its share to this average. He is especially gratified at the advances made in industrial education, welfare work, and the relations between workman and employer, advances which, we are glad to say, have been largely brought about by the efforts of such broad-minded men as the president of the great works at Mishawaka.

The Automobile for Army Use

RECENT editions of newspapers in different sections of the country contained an interesting article, quoting Mr. E. H. Barnum, New York branch manager of the Regal Motor Car Company and a National Guard officer in his State, relative to the possibilities of the automobile in the army. Mr. Barnum says that, as a result of the article, he has received many letters from inventors, would-be inventors and fanatics, making inquiries and soliciting his aid with a view of bringing inventions forward to public attention.

MANUFACTURING NEWS

A Popular Tool



FAY & EGAN NO. 61 HAND PLANER AND JOINTER

ONE of the most popular tools in the workshop of the pattern-maker, carpenter and general woodworker is the hand planer or jointer, and we illustrate herewith a machine for this work, built by the J. A. Fay & Egan Company, of Cincinnati, Ohio, called by them No. 61.

This machine is extremely simple in construction, consisting of a revolving cutter head placed between a pair of tables, which latter are independently adjustable, both horizontally and vertically, being mounted on and tongued into inclines. By screw and hand-wheel movement the adjustment may be made on the micrometer principle, while the tables may be immediately drawn away from the cutter head to give access to the knives, permitting setting, changing, or replacement.

The cylinder itself is made of forged steel, slotted, and with four sides, and is mounted in self-oiling reservoir bearings. The manufacturers furnish their safety cylindrical cutter head with this machine, when so ordered. The fence may be inclined to 45 degrees for bevel planing, and is provided with spring post for holding down material when passing over the cutter head.

With such a machine in the shop there is no shoving of hand jointing planes, and the work is done far more rapidly, as well as more accu-

ately, than is otherwise possible. It is applicable to general jointing and rabbeting, for planing straight or out of wind, for cornering and chamfering, for making glued joints, and for a great variety of miscellaneous work.

A large illustrated circular giving further information may be obtained by writing to the manufacturers, the J. A. Fay & Egan Company, 226-246 W. Front street, Cincinnati, Ohio.

Personal

Dr. J. A. L. Waddell, the noted bridge engineer, of Kansas City, recently delivered two lectures before the faculty and students of the College of Engineering of the University of Illinois, one a technical talk on "Materials of Bridge Engineering and Foundations" and the other a general lecture on bridge construction.

Dr. N. Clifford Ricker, of the Department of Architecture of the University of Illinois, has been appointed a member of a Commission of Awards to judge and to report upon the relative merits of the designs and plans submitted in competition for three department buildings to be erected in Washington, D. C. The Commission began its sittings on the 4th of January.

Mr. F. O. Bolles, commercial engineer of the Allis-Chalmers Company, has resigned, in order to devote his entire attention to the Reliance Engineering & Equipment Company, 1417-19 Majestic Building, Milwaukee, in which he has an equal interest with C. A. Tupper and others. The company, which is taking on a number of additional exclusive agencies, has its new offices at 415, 416 and 417 Engineering Building, and has considerably extended the scope of its operations.



THE LATEST CATALOGUES

Steel Belt Lacing

All users of belts will find of value the catalogue recently issued by the Bristol Company, of Waterbury, Conn.

The Bristol patent steel belt lacing is so widely and favourably known and used that it needs no introduction, as it has proved its worth for fastening rubber, cotton and woven belts as well as leather ones. In fact, they manufacture a lacing for use with all kinds of belts. Illustrations are given of the original form, or No. 1 style, of belt lacing, and also of four different styles of Bristol lacing ready to apply and applied to actual sections of belts.

Electric Pyrometers

Bulletin No. 130 is a 56-page illustrated catalogue of the Wm. H. Bristol electric pyrometers, and includes description and lists of both indicating and recording forms of these pyrometers, with explanation of the special patented features—as, for instance, basic patents on means of compensating readings of thermo-electric pyrometers for changes in cold end temperature. On pages 48 to 55 of this catalogue a partial list of more than 700 users of the Bristol pyrometers is given. A copy can be obtained from the Bristol, Company, Waterbury, Conn.

Steel Sash

A new catalogue, with many illustrations, has been published by the Trussed Concrete Steel Company, of Detroit, Mich. The book will prove of service to those having to do with the fireproof construction of factories, foundries, warehouses and industrial buildings of any nature.

Billing and Accounting Machine

From the Monarch Typewriter Company, 300 Broadway, New York, a descriptive and illustrated catalogue of their Monarch condensed biller, retail bill and charge machines, unit order machines, way-bill machine, card writing machines, label-writing machines. Their attachments will do much to lighten labour, save expense, and improve outfit. Their claims for the Monarch are durability, visibility, accessibility, and extreme lightness in touch and operation.

Mallet Articulated Locomotives

The Baldwin Locomotive Works, of Philadelphia, Pa., have recently issued Record No. 68, giving a vast amount of information concerning this type of locomotive, which was first placed in service on American railroads in 1904. Their arrangement results in a locomotive of high power, with a comparatively short, rigid wheel base, and moving parts of relatively light weight, with wheel loads kept within reasonable limits. The more important improvements introduced by the Baldwin Locomotive Company in the development of this type of locomotive are described in this book. A copy can be obtained by addressing them.

Fan Dynamometers

A fan dynamometer designed especially for the absorption and measurement of power developed by internal-combustion motors has been placed in the market by Joseph Tracy, consulting engineer, 116 West Thirty-ninth street, New York, and is fully described in a catalogue to hand from him.

MANUFACTURING NEWS

Air Compressors. Radialaxe Air-Driven Coal Cutters, Pneumatic Tamping Machines

The following descriptive catalogues are received from the Ingersoll-Rand Company, 11 Broadway, New York:

Booklet No. 3,007 deals with the latest design in power-driven air compressors. The principal features are enclosed, dust-proof construction, with automatic flood lubrication for main bearings, crank-pins and cross-heads. These compressors also have increased wearing surface, large valve areas, and greater intercooler service. The principal new features in this pamphlet are the water separator and the clearance controller, described on pages 13 and 20, respectively.

Booklet No. 5,003 describes the Radialaxe air-driven coal cutter. This machine is designed for under-cutting in a pitching seam, shearing, mining in the middle of the seam and cutting out bands in the coal. It is in essentials a long-stroke drill, provided with a method of mounting especially adapted for the class of work for which it is intended. It is easily operated, and has distinct advantages over other machines in doing the kind of work for which it is designed.

Booklet No. 9,008 describes pneumatic tamping machines for relining copper converters. They are built on the same general design as the company's rock drills, with modifications to meet the requirements of this work. It is a great saver of labour, small machines doing the work of from six to ten men, and the large ones nearly three times as much.

The company will send copies to anyone interested, and will also send a copy of their work descriptive of the Davis "Calyx Diamondless" core drills, the function of which is to determine, by means of cores or cylinders extracted from an annular hole, the character; order, thickness and extent of materials beneath the earth's surface.

Mine Fans

The Jeffrey Manufacturing Company, Columbus, Ohio, have just issued a new and very complete catalogue on their centrifugal fans for mine ventilation.

This publication is one of the most complete catalogues on this subject that has so far been issued, and contains useful information for the mine man who is interested in this important subject of mine ventilation.

It is a very fine piece of work from the printer's viewpoint, and contains numerous illustrations showing Jeffrey fans installed in various mines throughout the country.

The book also contains the latest bird's-eye view of the Jeffrey Manufacturing Company, which is the largest plant designing and building complete mine equipments in the world.

The Jeffrey fan catalogue also contains various photographic illustrations showing the shop methods of constructing the fans; also, their unique method of balancing the fan wheels and assembling all parts of the fan casings, and also many views showing the applications of different types of fans at over fifty different mines. The capacities and other important machinery data are also given with every installation, as well as complete tests with the reproductions of the actual indicator cards, showing the high efficiency of the Jeffrey fan.

There are also a number of pages with reproductions of drawings giving a comprehensive idea of the general arrangement of foundation work necessary for Jeffrey fans.

Other valuable and interesting features in this catalogue are the engineering data and formulas, which are arranged in convenient form for reference by mining engineers and operators who have ventilating problems under consideration.

The Jeffrey Manufacturing Company will send this catalogue out to any of our readers who request it.

Commercial Efficiency

MANUFACTURERS, whether of merchandise or of power, are beginning to realize that there are several methods of operating a business so as to secure a profit. The old rule of buying cheap and selling dear was a very good one so long as other people did not perceive the extent of the operation; but it has been very greatly limited by the extension of methods for the transmission of intelligence ahead of the markets, apprising both rivals and customers of the actual value of the wares.

Another plan, and one which has been largely developed in late years, involves the control of both supply and opportunity for sale, a method which, however, requires immense capital and special privileges for its successful manipulation.

Of late, however, much attention has been directed to another plan for securing a profitable outcome for a manufacturing business, a plan which, it is rather surprising to note, has not been adopted very generally long ago. This idea is the simple one of reducing wastes within the establishment itself, so as to cut down the manufacturing costs, and thus increase the margin of profit without demanding any increase in the selling price of the manufactured product.

It is not always possible to determine just what the maximum efficiency of a man, a machine, or an entire manufacturing plant should be; but it is practicable to get an idea of the locations where the wastes are occurring, and to estimate about how much the efficiency might be increased by the replacement of the man by the machine.

In some departments of work human effort is the most efficient which can be employed, especially when it is accompanied by individual skill, good judgment, and an honest assumption of responsibility. There are other situations—and these are probably in the majority—in which the machine is better than the man,

and in which it is muscular energy rather than mental effort which is demanded by the work.

It is generally conceded at the present time that the proper effort of a man is that which is exerted in directing power machinery, and not in doing the work by his own unaided energy. This is particularly true of such work as the shoveling of coal and the removal of ashes. It has been estimated that, even in such skilled work as that of the bricklayer, much of the effort is that expended in the movements of the body of the workman, bending down to pick up the brick and turning and examining it before placing it in position. This being true, it is evident that even more unnecessary effort is required for the man who, in shoveling coal or ashes, must move his own weight to a large extent with every shovelful which he handles. Here is but one source of the inefficiency of human labour as applied to this particular work, and there are others which will be as apparent upon observation. The question of time alone is sufficient to cause the machine to offer superiority, not only in the operations directly affected, but also in the efficiency of the entire establishment.

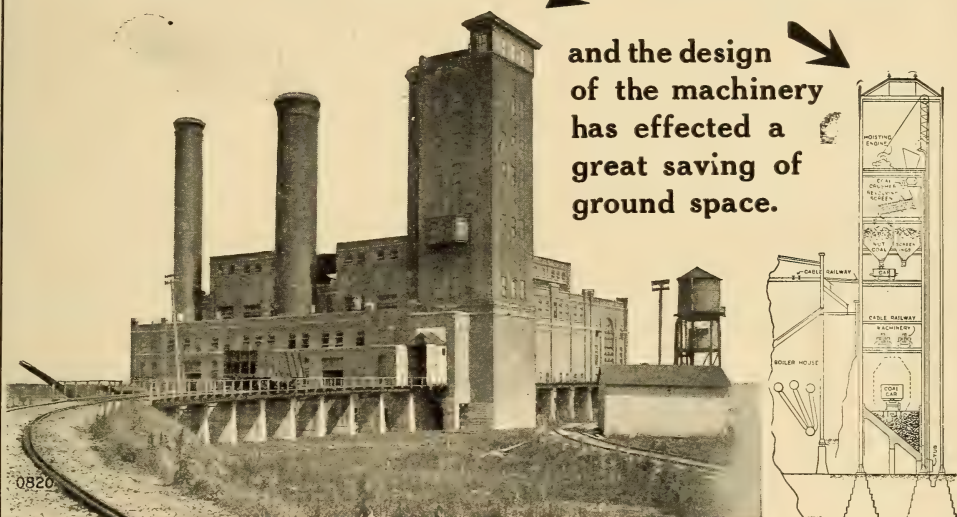
Another point, and one which is frequently overlooked, is the notable economy in space which may be effected by the use of coal-handling machinery, since the operation, instead of being spread out over considerable area, may be concentrated into a small amount of floor space, and relegated to tower or other elevated portions of the building not otherwise available for service.

When all these various elements which go to make up economy as a whole are combined in a single plant, as they well may be when the extended experience of specialists in such work is employed, one of the most important methods of reducing wastes and increasing efficiency in the operation of a power-generating plant will be secured.

Fuel Handling Economics

The diagram shows a unique arrangement of the coal and ashes handling machinery at the Power Station of the Edison Electric Company, Delray, Mich. The installation is located in the tower of

and the design of the machinery has effected a great saving of ground space.



Economical use of time and labor

Our specialty is the economical handling of coal and ashes in Power Stations, and our engineers are ready to study your particular case and apply the cheapest and most modern methods. They are at the service of any present or prospective customer. Call on them to solve your problem.

**Hunt Noiseless Bucket Conveyor
Hoisting and Conveying Machinery
Industrial Railways**

Steam Shovels

**Electric Locomotives
Cable Railways
Automatic Railways**

C. W. Hunt Co., West New Brighton, N. Y.

N. Y. City Office, 45 Broadway

ATLANTA, GA., 607 Rhodes Building
RICHMOND, VA., State Bank Building

CHICAGO, 1616 Fisher Building
SAN FRANCISCO, 865 Monadnock Building

Picking up Money

THE value of any article of merchandise depends to a very great degree upon its location. Even those things which require little or no application of manufacturing processes to render them merchantable must be transported from the places where they are found to the locations where they can be used or their value is only potential. This is true to a still greater extent with manufactured products, so that the question of transportation sometimes becomes the controlling power in commerce and trade, and possesses a material influence upon costs and prices.

This relation of transportation facilities and commercial development has, until recently, been considered principally in connection with external relations, as affecting the supplies of raw material and as regulating the distribution to various markets. With the development of attention toward the improvement of internal efficiency in manufacturing, however, it is beginning to be realized that the matter of transport within an establishment may be almost as important as it has already been found elsewhere.

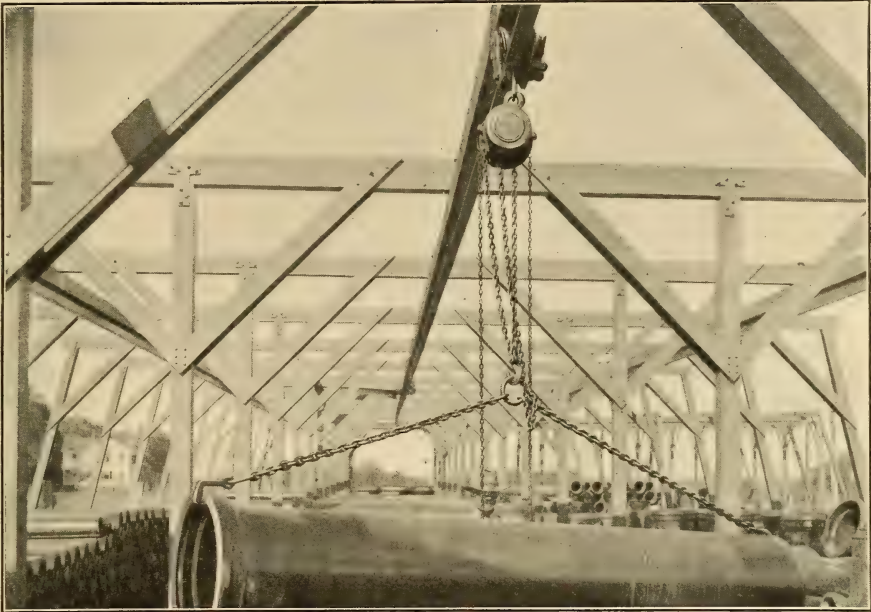
One of the fundamental principles of modern efficient management is that of the maintenance of the flow of material and work through the establishment with as few interruptions as possible. The best returns can be obtained from high-priced workmen and costly machines only by keeping them continuously at work upon productive operations, and by reducing to a minimum the periods of waiting for material or for removal of completed jobs. The whole operation of supervision includes the maintenance of a system of movement which shall be practically uninterrupted, and anything which acts to check such movement interferes with efficiency almost as much as does a blockade to the operation of a street railway.

The extent to which these facts are being appreciated appears in the manner in which modern manufacturing establishments are fitted up with improved mechanical appliances for handling material and work.

Thus very widely used we see the chain hoist used to carry loads of any character or size. When such a hoist picks up an article from a storage point and delivers it to the location where it is wanted, it has, by that very movement, converted its potential value to an actual value, and in that sense it has actually picked up money to the extent to which the value has been increased. There are various ways of estimating the amount of money which has thus been picked up, but perhaps one of the most obvious is to find out just what would have been paid in wages if the operation of transport had been wholly effected by manual labour. The mere wages would amount to a respectable sum, while the loss in time incurred by the slower movement would mean additional cost, measured by the value of the men and machines which were kept waiting for the service.

In like manner the loss of time in getting off the shipment, or of unloading a car, and of utilizing storage space, may be computed in money, and when the stoppage of such losses may be effected by the use of tramrail and chain hoist it will be seen that the expression "picking up money" is a distinct truth, and not a mere figure of speech.

At the present time, and in many departments of work and activity, it is in just such ways that money may be saved and profits acquired. When the internal losses and wastes of an establishment are checked and costs proportionately reduced, the influence upon the balance sheet is as marked as when selling prices are raised, and in many instances the former method is possible when the latter cannot be effected.



IN USE IN A STORAGE YARD—Triplex Block hung from a Brown Patent Steel Plate Trolley and running on an overhead I-Beam Track, for handling cast iron pipe in a store yard.

Here—There—Everywhere

The Triplex Block shown in this picture gets all over the place.

It's picking up money every hour in the day—by saving time and labor in handling materials.

And the best of it is that it will go on saving money year in and year out.

It has the simplest, strongest, most efficient gear-system ever built into a chain block—that's why it leaves all other chain blocks far in the rear.

Your dealer will lend you one to try—or we will if you haven't one near.

Triplex Blocks { 16 Sizes: One-quarter of a ton to forty tons.
300 Active Stocks ready for instant call all over the United States.

Send for the Book of Hoists today—Yours for a postcard

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Fairbanks Co., Ltd. Offices in
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In writing to advertisers, please mention CASSIER'S MAGAZINE.

CASSIER'S MAGAZINE

Holding On

ONE of the qualities which is often emphasized as making for success in any undertaking is the ability to "hold on." Many men can do good work under favourable conditions, and of such it has been said that nothing succeeds like success.

The man who can hold on to an undertaking when success is yet in the future, and when the best and most difficult work must be done under discouraging surroundings, however, is of a higher grade. He it is who wins out for the great rewards, and he is the exceptional one in the race for success.

As with men, so this is true with mechanical appliances. It is the device which meets emergencies, which can carry the heavy and unexpected burden, which receives the highest approval. Sometimes this is literally true, and especially so in connection with the question of the transmission of power. The direction of power is one of the broadest and most comprehensive acquirements which distinguishes the civilized man from the savage, and it is a department of the work of the engineer which has done the most for mankind.

In order that power may be transmitted and directed with intelligence, the apparatus of control is necessarily most important. Power, like some other things, is a good servant, but a bad master. The bursting boiler, the runaway engine, the slipping belt, the erratic clutch—these represent power imperfectly controlled, working destruction, or at the least, inefficiency. On the other side of the picture stands the steadily-governed motor, the swift-pulling belting, the stiff, truly-aligned shafting, and the clutch which holds on or releases, at the will of the operator, for whom all these elements are working.

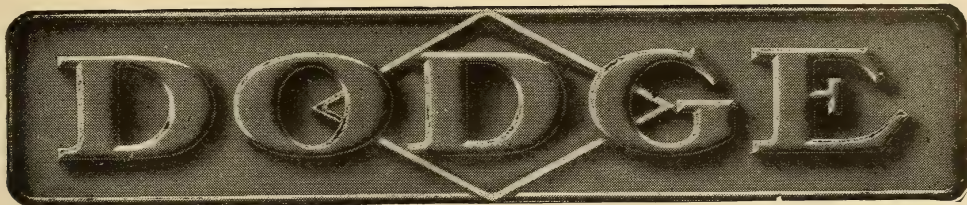
The clutch itself forms an essential part of a successful transmission system. It must "hold on." That is what it is primarily made for, and

what its name implies; but it must also let go at the right time and in the right place.

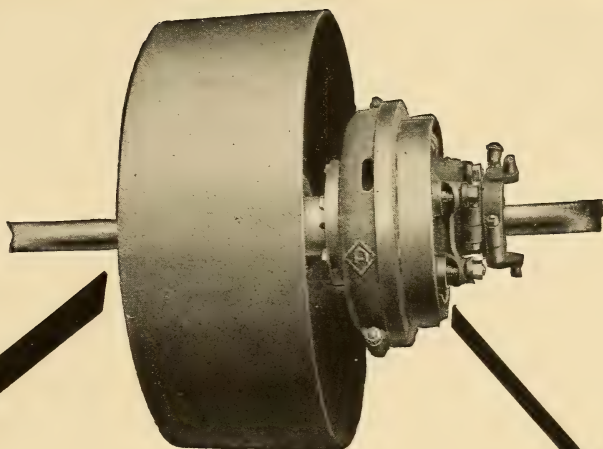
If these two requirements were all, they would be met by some of the earlier types of jaw clutches, with heavy prongs to engage with each other abruptly and to let go with equal suddenness. But there are other considerations to be met, questions which are properly included in and essential to real control. Control of power involves its intelligent direction, and when this is effected by a modern clutch it includes the gradual engagement and release which precludes shock or abruptness and prevents trouble. The engineer knows that power is composed of three elements—force, motion, and time. If he is to have real control over this complex servant, therefore, he must be able, not only to supply or withdraw the force and to give or withhold motion—he must govern the time during which these effects are produced; he must master each separate component at will.

The real clutch supplies these elements of control to a surpassing degree. It can hold on or let go, giving the force its grasp or its release; and the grasp is positive and the release equally sure. As it engages, it transfers motion from the one portion of the transmission to the other; and with release, the movement beyond is stopped. At the will of the operator the time element enters, and the engagement may be graduated over a long or short period, as he may desire. Behind the clutch is continuous, uniform, steady power; beyond it is power controlled in each and all of its three elements.

When a clutch can be depended on to do these things it becomes one of the most useful servants which the engineer has placed in the hands of man; it converts a source of power to his use and convenience, and it renders practicable a distribution and use of energy otherwise possible only in an irregular, inefficient and possibly dangerous manner.



Here's A Clutch That Makes Good



THE Summit Thread Co., East Hampton, Conn., who use the Dodge Split Friction Clutch, recently wrote us—"We have been using one of your clutches for about three years, and while our experience with friction clutches in general has been rather unsatisfactory, the clutch of your make has never caused any trouble whatever."  The Dodge Split Friction Clutch is a real service-giver. It is doing the hardest kind of work in rolling mills, cement mills, rubber mills, mines and smelters and other industries. Some of the largest concerns in these lines have adopted our clutch as their standard, after exhaustive trials and tests of clutches of different makes.  Dodge Clutches are dependable power-savers. Each department, each lineshaft, even each machine throughout your plant may be controlled independently of all the balance of the equipment. Consider the immense saving in power by shutting down idle machines, by having the equipment under instant control in case of accident to men or machinery.  We will be glad to advise with you about Dodge Friction Clutches to exactly meet your requirements. Write us about your possible clutch needs.  Your name on the coupon brings our Clutch Bulletin C-116, which tells about this "economy mechanism".

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The Influence of the Rock Drill

A ROCK DRILL is not, at first thought, the thing to attract the interest of the mechanically inclined. Those least informed about it are apt to pass it by with a casual and indifferent glance as a simple machine doing only the roughest of work. No one ever thought of putting a bit of finish on the outside of it, or even of painting it, except with the thought of protecting it from the weather, and even the paint is always coming off second best in its encounter with mud and flying rocks.

Nevertheless, the rock drill is one of the great inventions, and a composite invention at that, to whose development many untiringly ingenious minds have contributed. No machine was ever more completely fitted for the strenuous life or lived it more successfully. Besides its actual work in breaking the rock and releasing the mineral treasures, in cutting the ways of traffic for the commerce of the world, whether borne on the land or on the water, in excavating foundation sites for the heaviest structure ever erected by man, its incidental influences and achievements also evidence its epoch-making importance.

It introduced and made familiar the air compressor, which now finds employment in vast activities to which the rock drill is only remotely related. George Westinghouse told recently how information of the driving of the first rock drills by air in Alpine tunnels put him upon the right road to the air brake. The entire line of air-driven tools, the pneumatic hammers, riveters, caulkers, rotating drills, direct and motor-driven hoists, and the rest, are the children and the grand-children of the original rock drill, and the industries in which these are employed and depended on owe their rapid growth to it.

It was noted recently, upon the death of Chas. T. Porter, how the exacting requirements of the high-

speed engine and his careful supervision of its manufacture had done much for the promotion of accurate and efficient methods of machine work in the shops of the world. Nothing has been more insistent upon accurate workmanship, precise reduplication, and especially upon the adaptation of the different materials to the several parts than the rock drill. In a way the requirements of the rock drill as to precision of manufacture are as exacting as those of the linotype machine. All the working parts of each individual drill must fit with precision, so that they will work with absolute freedom and yet permit no leakage of air. All members, even to the entire machine, must permit of being taken apart by anyone, anywhere, and then of being assembled again, all without any kind of packing.

This is simple enough, perhaps, for the individual drill; but this drill is usually taken apart only because something has gone wrong with it, and when the working conditions of the drill are considered, and the neglect and abuse and accidents to which it is subject are remembered, this is to be expected. In the reassembling of the parts, therefore, some of them will probably have to be replaced by new ones taken from the stock of duplicate parts always at hand. This may be in Michigan or Montana, in Africa or Australia; but the new pieces slip into their places and are at once ready for their work, as though they had always been associated with that particular drill. This is one of the wonders of modern manufacture.

If any poor inventor is hoping to introduce some new machine of a calibre at all commensurable with that of the rock drill, he could not fail to be impressed, if not appalled, by the enormous plant, the variety of ingenious machines, largely automatic, and the crowd of variously skilled workers employed in the production of the rock drill.



FINANCIAL NOTES OF THE INDUSTRIAL WORLD

Demand for American Machinery in South America and Mexico

The extent to which the markets of South America and Mexico are open to manufacturers of power-generating equipment, electrical machinery and hydraulic machinery is apparent from the reports which are continually being received from prominent American manufacturers. The following notes are but a portion of the work being done by a single concern in the United States for concerns in sister American Republics:

The Rio de Janeiro Tramway, Light and Power Company, Rio de Janeiro, South America, has placed an order with the Westinghouse Electric & Manufacturing Company for two 2,500-KVA., 3,000-R. P. M., 6,300-volt, three-phase, 50-cycle turbo-generators. The Westinghouse Machine Company will furnish the turbines, which will be equipped with No. 11 Leblanc condensers. This equipment will be placed in a new station, which will operate in connection with the power company's water power station. The station will be located in the city, and will be used only when the water is low and the water power plant cannot deliver its full rated capacity.

The Cia. Beneficiadora de Pachuca de Mexico has recently bought one 915-KVA. O. I. S. C. auto-transformer from the Westinghouse Electric & Manufacturing Company, Pittsburg. The three-phase, 10,000-volt, high-tension—6,600-volt,

low-tension transformer is designed to operate on either 50 or 60 cycles, and will connect together two systems, one of 10,000 volts and the other of 6,600 volts, in case of failure of either system. The transformer will be able to switch the 1,000 horse-power load of a compressor motor from one circuit to the other in case of failure of the circuit that is operating.

Rapid Increase in Trade with Our Colonies; More Than Doubled Since 1893

THE trade of the United States with its contiguous territories, as shown by the Bureau of Statistics, has greatly increased during the last seven years—in fact, has more than doubled.

In 1903 the trade with Alaska, Hawaii, Porto Rico, the Philippines, Guam, Tutuila and the Midway islands amounted to \$100,107,234. Seven years later, in 1910, it amounted to \$202,494,343. During the same period the value of the merchandise shipped from the territories to the United States increased by 82 per cent., while the value of merchandise shipped to the territories from the United States shows an increase of 139 per cent.

Manufactures and foodstuffs formed the principal articles which were shipped to the territories during the last year, and it is of interest to note that \$750,000 was invested by Hawaii alone in automobiles during the year.

Large Increase in Demand for Flake Graphite

The men who have made a careful study of lubricants and who are connected with steam railroads and automobile companies as experts on the subject of proper lubrication, have very plainly shown what they think of Dixon's Ticonderoga flake graphite and the graphite lubricants of which Dixon's flake graphite, either regular flake or finely powdered flake, form the basis.

During 1910 the Joseph Dixon Crucible Company supplied graphite and graphite lubricants to 210 different steam railroad companies. Its business with the steam railroads increased 53 per cent. During 1910 the Joseph Dixon Crucible Company sold graphite or graphite lubricants to ninety-one automobile manufacturers and increased its business with them 260 per cent.

Dixon's flake graphite, regular flake and finely powdered flake, and Dixon's graphite lubricants are in every way looked upon as standard and without an equal.

A Quick Recovery

The principal plant of the Star Expansion Bolt Company, located at Bayonne, N. J., was almost entirely destroyed by fire early Friday morning, January 20, the loss to buildings and machinery being almost complete. The stock of manufactured merchandise, however, was but slightly damaged, and they report that they were enabled to resume deliveries without interruption Monday, January 23.

The general and executive offices of the concern are located at 147-149 Cedar street, New York, with branch offices and warehouses in Chicago, San Francisco, New Orleans, Montreal, Toronto and Winnipeg. This concern carries heavy stocks at all of its branch warehouses.

A New \$1,500,000 Court House

That sidewalk lights are practical indoors as well as out is demonstrated by the construction of the new Court House of Shelby county,

in Memphis, Tenn., where the "Raydiant" sidewalk lights manufactured by the Berger Manufacturing Company, of Canton, Ohio, are in use.

The lights were installed largely in the courts of the huge building, which is one of the handsomest and most magnificent in the South. The cost of the building was \$1,500,000. The architects for the Court House were Hale & Rogers, of New York. Perfect light is an essential in a county hall of justice, and it was only after a thorough test and demonstration of the light-giving qualities of the "Raydiant" system that the lights were contracted for.

Installation of Monorail Overhead Tramway System in J. H. Ladew's New Mammoth Tannery

The Yale & Towne Manufacturing Company has been awarded the contract for installing a complete monorail overhead tramway system for the J. H. Ladew Company's new mammoth tannery, Plank Road and Passaic River, Newark.

The equipment comprises about three-quarters of a mile of I-beam, three traveling cranes, transfer devices, automatic fire door attachments, etc., etc., and is notable as showing the tendency toward overhead or "aerial" transportation for the handling of materials in up-to-date manufacturing establishments.

The Far East Purchasing Electrical Equipment

American manufacturers are receiving contracts for power and electrical equipment in the Far East, as the following note indicates:

"The Westinghouse Electric & Manufacturing Company has just received an order for one 200-KVA. rotary converter, two 125-KVA. O. I. S. C. transformers and one three-panel switchboard for shipment to the Nikkon Gas & Electric Company, Nikkon, Japan.

"The rotary will be used on street railway service. It is designed for operation at 365 volts, two-phase, 60 cycles A. C., and 550 volts D. C."



THE LATEST CATALOGUES

Brazed and Welded Tanks and Cylinders

A handsome catalogue is just received from Wm. B. Scaife & Sons Company, Pittsburg, Pa., fully describing their well-known line of range boilers and high-pressure tanks.

This firm, which has long been famous for the high efficiency of its products, manufacture an extensive assortment of range boilers, tanks, stacks, ice cans, corrugated iron high-pressure cylinders, water filters and water-purifying plants. Their underground gasoline tanks are largely used for automobile garages, motor boats, gasoline engines, etc. The book presents in convenient form much information of value.

Lime Kilns and Lime Burning Equipment

Announcement is made of its new line of lime kilns and lime-producing equipment by the Improved Equipment Company, 60 Wall street, New York, in their new Bulletin No. 4. This bulletin contains, besides a description of the company's apparatus, a discussion of the principles and economies of lime manufacture. The company not only builds its own apparatus, but is also prepared to design and install complete lime plants, assuming entire responsibility therefor.

Rock Drill Mountings, Steels, Hose, etc.

Bulletin 9,003, issued by the Ingersoll-Rand Company, of New York, under the above heading, describes and illustrates the complete line of drill equipment which the Ingersoll-Rand Company is prepared to furnish. It also includes tables giving sizes, weights and prices, etc., of the equipment described. The company will be glad to send a copy to anyone on request.

Steel Window Sash

A catalogue that at once attracted attention on its receipt was the one recently issued by the Detroit Steel Products Company, Detroit, Mich. Its cover of black, with embossed illustrations and lettering in red, is striking for its neat appearance, and is in good keeping with the exceedingly attractive appearance of their steel sash. The book consists of 35 pages, 9" x 12", and is printed in two colors. The "Detroit-Fenestra" solid steel sash in standard sizes was first offered to the public three years ago, and the constantly increasing demand for their steel sash has proved the wisdom of their plan of standardizing this product.

The catalogue takes up in detail all the special construction features of their sash, such as the "Fenestra" joint, fillings, sections, etc., the sizes of standard sash, with illustrations, gives instructions for erection and for glazing, and also contains illustrations showing many large buildings where their sash is in use. There is also a page devoted to a few of the prominent users of their sash, a glance at which will show the esteem in which they are held by a large number of the great concerns of this country. This catalogue is well worth having, and can be obtained by addressing them.

Elevator Controllers

A booklet describing the line of electric elevator controllers developed by J. L. Schuremann Company, of Chicago, and now made by the Cutler-Hammer Manufacturing Company, of Milwaukee, is received. It contains a very full and clear description of this effective controller and has many illustrations. A copy can be obtained by addressing the Cutler-Hammer Company.

Discounting Your Coal Bills

ANYONE who has ever been near the coal mining districts of the United States knows that excellent fuel may be obtained on the spot for a far lower price than is paid in the distant manufacturing centres. The manufacturer also knows that a considerable proportion of the price which he pays for the fuel burned under his boilers is due to the cost of transportation. At the same time, he would be surprised to be told that he himself was one of those who added to the cost of his fuel a percentage equal to a very fair profit on the whole amount, a profit which, possibly, he is unable to obtain on the articles which he is manufacturing for sale.

The cost of coal is generally taken as the amount which has to be paid out per ton delivered on the wharf or in the yard of the purchaser. As a matter of fact, this is by no means the entire cost, unless it is bought to be sold again, and the delivery charges begin from the point where it has been received.

If the coal has been bought for use in making steam, its traveling expenses do not cease until it is delivered upon the grate under the boiler by which its latent energy is to be made active. Its real cost to the manufacturer, therefore, includes the handling, manual or mechanical, which brings it to the point of service.

Just how much this handling costs depends upon local conditions. One thing is well established, however, and that is, the most expensive way of doing it is by manual labour. The man, with shovel and wheelbarrow, can do the work; but the efficiency of this arrangement is low, and it can be improved only by close and continuous supervision, and not always then. In the modern scientifically managed plant the use of the man for such work has been replaced by the machine, and, when well designed, there is hardly any investment which will pay better

dividends than a machine to do the work of a labouring man. Just how valuable such an investment may be made appears in the case of an electric power plant which received its coal at a wharf 800 feet from the boiler front, and which, handling the coal by old-time methods, did so at a cost of $27\frac{1}{2}$ cents a ton, and reduced this cost to $3\frac{1}{2}$ cents a ton by the installation of an equipment consisting of a steam shovel, cable railway, storage pocket and conveyor.

When it is understood that this cost of $3\frac{1}{2}$ cents a ton included interest on the investment, and that the saving of 24 cents a ton was clear net gain, it will be seen that the economy of the improvement was well worth the expenditure. Assuming the coal to have cost \$2.40 per ton on the wharf, the saving amounted to 10 per cent. on the final cost delivered to the boilers, and any opportunity of securing such a discount on the coal purchased, by methods wholly in the control of the purchaser, would not be allowed to slip by under ordinary business conditions.

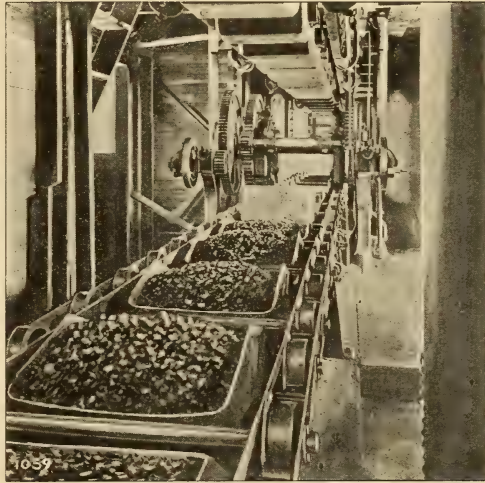
It has been shown that, in the ordinary power station, the cost of fuel ranges from 40 to 50 per cent. of the entire operating cost, so that an economy of 10 per cent. on the coal bill represents a saving of about 5 per cent. on the whole cost of running the plant.

In addition to the actual reduction in cost obtained by the installation of machines to replace men, there is secured, to a large degree, immunity from labour difficulties, due to the smaller number of men engaged and to the specialization of their duties. This alone is a matter which, in some cases, exercises a controlling influence upon the choice of equipment, and when it can be attained at the same time and by the same means as are employed to effect a reduction in operating expenses a double gain is apparent.

Power Plant Economics

Reduce the Cost of Handling the Coal and Ashes in Your Power Plant

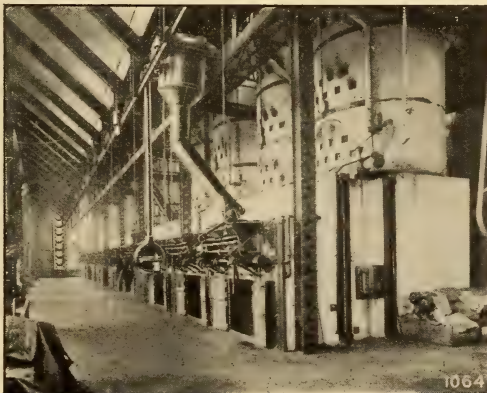
We will show you where a saving can be effected in your present methods by using "Hunt" machinery.



Hunt Noiseless Bucket Conveyor

Saved \$6000 a Year in Handling 25,000 Tons of Coal

Write us the work you wish to accomplish and we will submit a proposition which, from our long experience we know will make good. Our engineers are ready to study your particular needs and apply the most modern economical methods.



Boiler Room Weighing Hoppers

A Case in Point

At a power plant located 800 feet from the wharf, the cost of handling coal, previous to installing our machinery, was $27\frac{1}{2}$ cents per ton on 25,000 tons per year. By our method the coal was unloaded from vessels with a one-ton steam shovel outfit, carried to the storage pocket by a cable railway, taken from the pocket by a conveyor, and delivered to the front of the boilers for a total cost, including the interest on the investment, of less than $3\frac{1}{2}$ cents per ton. This installation paid them; above interest and all operating expenses, a net profit for dividends of 24 cents per ton or a total of \$6000 a year. Is this not worth considering?

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CASSIER'S MAGAZINE

The Hand and the Head

FORMERLY the men who performed laborious work were included broadly under the generic name of "hands." They were not supposed to use any judgment nor to do anything but use their muscular strength; they added the effort of their hands to that of other hands, thus collectively enabling greater force to be exerted than would have been possible for a single individual.

Naturally, the amount of power which could thus be utilized to advantage was exceedingly limited, and any attempt to employ the effort of a large number of men defeated its own purpose by producing such an involved and interfering effort as to do more harm than good. The introduction of mechanical devices which replaced a number of men was, therefore, a great step in advance in this important department of work.

Like all other kinds of work, the operations of hoisting, lowering and placing burdens were advanced just so far as the united effort of the hands was replaced by devices which permitted the man to employ his head more and his hands less. It was possible for a number of trained men to act together to lift a heavy load with a reasonably concerted action; but it was by no means so easy to train them to lower the burden, slowly, gradually and precisely, to a position required by the job. When, in addition to hoisting, it was desired to move the burden to a predetermined point and then raise or lower it to a final position, the whole affair became complicated to a degree which made it costly, unreliable and difficult.

The idea of using the head instead of the hands of the workman and replacing his muscular effort by the power of a convenient and portable machine wrought a great change in many departments of work. The ordinary lever permitted the effort at the long end to be multiplied sev-

eral times; the introduction of the rope tackle extended this useful idea still further, but it was not until the control of lowering, as well as hoisting, was included in the function of the machine that the whole operation was transferred from the hand to the head. When the effort of a man's hand is magnified thirty-fold by a machine which will stop when he stops, and will begin again, either upward or downward, only when he directs, there is introduced into human labour an element the importance of which can be only imperfectly grasped until it is seen in action. The elimination of two men out of every three in the ordinary operations of manual effort, and the replacement of the work of the hands of the third man by the judgment of his head—these things mean an increase in efficiency, directly of 66 per cent., and indirectly to an immeasurable amount, due to the saving in time because of the greater accuracy of the work.

It is not easy to measure the precise money value of such savings, but the economy may be determined indirectly by comparing the actual cost of the new way of doing things with the expensiveness of the older method. One man, even if he receives somewhat higher wages, will cost a determinate amount lower than three less competent labourers. If he accomplishes a greater amount of work, the proportionate economy is a matter of simple arithmetic. If, for any reason, it becomes necessary, temporarily, to return to the old way of doing things, the jump in cost furnishes a very forcible way of measuring the economy of the newer method. A few such experiences will prove that one man, using his head in the direction of the power of a modern hoist, is worth several times the ordinary effort of an untrained individual employing only his hands, apart from the general acceleration of the entire job under the impetus of intelligent application of machinery.



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Clean Water

THE general idea of dirty water is associated with water that *looks* dirty—that is, water which contains earthy matter in suspension. As a matter of fact, such water is often cleaner than water which has a limpid appearance, and in any case it is readily made clean by the simple operation of filtering.

When water is needed to be really clean, as for laundry work and for feeding steam boilers, something more than mere filtration is necessary to insure the removal of all extraneous substances. It is well known that soluble materials, such, for instance, as common salt, may be added to water without impairing its clearness. The use of salt water in steam boilers, however, was given a thorough trial in the early days of ocean navigation, and the injury done to the equipment and the waste of fuel occasioned led to the universal employment of the surface condenser and the use of condensed steam for pure boiler feed.

There are other things besides common salt which may be found dissolved in water, and some of them are more objectionable in boiler feed than salt.

It has been said that water is the universal solvent, and it is probable that no substance acts as a solvent on so many different substances as does pure water. The result is that nearly all water which has been percolated through the ground contains in solution some portion of the constituents of the various strata through which it has passed. When the rain falls on the surface of the earth it is practically pure distilled water, and so is ready to take up whatever it meets. When it emerges in the springs, wells and brooks it is no longer pure, but contains a number of substances in solution.

Everyone knows what hard water is, and how much trouble it makes in the laundry and how undesirable

it is for drinking purposes. The salts of lime which the water has taken up from the limestone strata in the ground prevent saponification, and, when such hard water is drunk continuously, there will be formed calcareous deposits in the joints, which lead to suffering and lameness.

If such water, however clean and sparkling in appearance, be fed into a steam boiler, the result will be similar in nature, and far greater in extent, than when passed through the human system. The boiler becomes lined with hard scale, preventing the transmission of heat from the fire to the water, and ultimately causing the burning and destruction of the sheets.

Clean water for the boiler, therefore, means water which will keep the boiler clean. It must have the suspended dirt filtered out, and it must have the sulphates and carbonates, which are invisible but ubiquitous, precipitated by the proper chemical reagents and given opportunity to settle out in a purifier before the boiler is reached. The only way to keep a boiler clean is not to let it get dirty. Put nothing but pure, clean water into it and its steaming capacity will remain unimpaired and its life prolonged.

One of the most undesirable things to do with a steam boiler is to make a water purifier out of it. A boiler is installed for the purpose of making steam, not for separating scale from water. The two jobs should be kept distinctly apart, and the work of the purifier should come first.

Formerly this was not always practicable; but, since the importance of the question has become realized, the manufacture of apparatus for making really clean water out of water that only *looked* clean has been developed to an extent that enables anyone who has to use steam to secure pure, clean water out of which to make it. The apparatus is ready and available; it needs only to be used.

This Apparatus Will Save Fuel, Save Your Boilers and Save Work

One concern who installed a Dodge "Eureka" Water Softener and Purifier reports a saving in fuel of 12%—another 7%—others from 10 to 20%. In our own plant, where we have a "Eureka" in operation, we find it cuts down our fuel bills about 15%. The saving depends on conditions. And in addition, a vast amount of work and of wear and tear on boiler room equipment is avoided.

This "Eureka" Water Softener and Purifier solves the most difficult problem of economical power plant operation—the elimination of boiler scale.

The bad effects of scale in boilers are well known—explosions, loss of heat transmission, and attendant evils. But it is hard to appreciate its prevalence without investigation. Our experience convinces us that there is scarcely a steam boiler in this country, fed with natural water, which is free from scale accumulation.

And the logical way to prevent scale is to provide the boilers with pure, soft feed water.

The "Eureka" Water Softener and Purifier

automatically treats and purifies the raw water before it enters the boilers, eliminating from it all scale-forming matter. This does away with the use of expensive "dope" and gradually removes all incrustation that may be in the boilers when the "Eureka" is first installed.

It prevents the formation of new scale, thus keeping the boiler tubes clean, so they will not pit, corrode or explode, and greatly prolongs the life of the boilers. It will take less fuel and heat to turn the water into steam when the heat does not have to penetrate a thick coating of scale. And there will be no need of cleaning the boilers every few days.

This is what the "Eureka" machine is doing at hundreds of power plants throughout the country. Doing it automatically, with almost no attendance and only about a half-hour's attention each day. And at practically no cost, because the saving made by the "Eureka" much more than offsets all the expense connected with it.

If you will send us a sample of the boiler feed water you are now using, we will analyze it and tell you just what the "Eureka" machine will do for you, what the cost will be, and how long it will take the apparatus to pay for itself.

Or, let us send you our Bulletin C-117, "The Water Question." It tells all about the "Eureka" Water Softener and Purifier—how it operates and what it does. Please fill out the coupon and return it to us at once for a copy of this book. Take this first step toward greater power plant economy—today.



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Friendly Co-operation of Rival Powers

A FEW years ago we were hearing discussions as to the relative claims of electricity and of compressed air to employment for specific lines of service. There is, however, little talk now of electricity versus compressed air, or *vice versa*, because each has pretty completely demonstrated what it can do better than the other, and both now have their lines of employment rather definitely settled. The most noticeable thing, perhaps, is how each has helped to extend the working field of the other, or, from the viewpoint of the case which we have immediately before us, we might be tempted to say how much compressed air has done to provide employment for electricity.

In some of the situations which occur it would seem to be difficult to settle the claims of the rivals. For instance, where a water-power, hitherto unused, is "harnessed" to drive a generator, and where the current after transmission, perhaps for many miles, is applied to a motor which, in turn, actuates an air compressor, we might say either that the air compressor has provided employment for the electric current or that the electric current has done a good turn for the air compressor and made possible its location there.

In the case of the electric-air drill the matter seems to be much simpler and clearer. Electricity unaided has had its try at rock drilling, and it cannot be said that it has made any such success in that field as has the air-driven drill, nor is there apparently any likelihood that it will ever be able to, so that for operating rock drills it has almost ceased to be thought of. In the electric-air drill, however, electric current is the only power transmitter, and, in a way, electricity might be said to be solely responsible for and solely to be credited with the results; but it is the air at the drill which actually does the work, so that, after all, every electric-air drill in operation represents so

much employment which electricity would not have had except as it was provided for it by this ingenious air device.

The amount of the additional employment thus provided for the electric current is not immediately apparent. The electric-air drill incidentally leads the way to the employment of electricity for other purposes; for, where it has heretofore been imperative to have the air compressor to drive the rock drills, the presence of the compressed air on the spot has led to its employment also for the driving of pumps and hoists and such things; but the advent of the electric-air drill at once makes it possible to dispense with the air compressor and the air pipes entirely, and to use the electric drill for everything.

The electric-air drill gets additional and exclusive employment for itself and for the current which drives it through the part that it may be conveyed to and installed and operated in the most inaccessible places. It can make itself at home wherever men can get it, wherever the wires can be laid, and where it would be impossible to lay air pipes or to convey and operate an air compressor within practicable reach of the work.

All the other drills cost more to operate at the higher altitudes, but the electric-air drill is unique in that in operation it is entirely independent of the altitude. The air which operates it being entirely enclosed and not in touch with the external atmosphere and not expanding into the atmosphere, it makes no difference how much or how little the pressure of it may be.

The electric-air drill, it is to be remembered, comprises or sacrifices nothing of efficiency or advantage as compared with the air-driven drill. It strikes a blow as sharp and hard as ever was known; it can be moved and set and operated as easily as any, and it costs at the power house less than one-half what other drills cost.

"ELECTRIC-AIR"

ROCK DRILLS



A GOOD RECORD IS PROOF OF SUCCESS

When a new machine representing a moderately large investment finds, in its first five years, a world-wide distribution and sales running more than a thousand, there is pretty conclusive proof of sterling merit.

This has been the record of the "Electric-Air" Drill. It is not a cheap machine, as compared with the price of a single rock drill.

But for fairness' sake its price must be compared with that of a boiler and compressor, as well as of the rock drill. For it takes the place of all these.

The "Electric-Air" Drill has gone into most of the mining districts of the world, and has "made good" wherever it was given a fair chance.

The aggregate sales have run well beyond the first thousand, and among the large users may be mentioned the great Homestake Mine, at Lead, So. Dak.

We do not claim that the "Electric-Air" Drill is universally adaptable. But there are conditions where it is the best drill for the work.

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Mechanical Truth

ONE of the fundamental shop operations in all departments of machine construction is the production of a truly flat surface. Formerly this was considered a test of the skill of the trained journeyman, and a true surface was supposed to be producible only by the expert use of the scraper in the hands of the skilled workman, in connection with frequent careful comparisons with a standard surface plate. Even this laborious operation could be effected only upon materials upon which the scraping tool could make an impression, and until the development of the modern grinding machine the truly flat hardened surface was a thing almost incapable of commercial production.

When the grinding machine was first introduced it was employed in connection with a wheel revolving in a vertical plane, tangent to the surface to be ground, and, for cylindrical pieces, revolving while being ground, such machines produced excellent results. The use of a vertical wheel for producing plane surfaces, however, is, on the face of things, a mistaken idea, since the wheel itself can do nothing more than make a hollow corresponding to its own diameter, and the movement of the work beneath its perimeter means that the best that can be done is the reproduction of the ways upon which it is moved. Under such conditions the use of the grinding machine has been beset with numerous difficulties, and, although some good results have been obtained, they were due rather to the care which had been given to the construction of the machines rather than upon the correctness of the principle.

With the development of improved grinding machinery, however, it has become possible to produce results which are far superior to any obtainable under the old conditions, either by hand or by machine. The grinding wheel has become a cutting

tool, acting, not only by abrasion, but by actual cutting, so that the reduction of the material is effected as truly as in the lathe or the planer. By the employment of the horizontal, cup-shaped wheel, covering the full width of the work, all surface errors are eliminated in a manner impossible to correct either in the milling machine or with grinding machines using wheels revolving in a vertical plane.

The ability thus to produce truly flat finished surfaces upon hardened pieces is especially important in connection with the machining of thin pieces, which are liable to warp in hardening, since any such deformation is wholly corrected in the subsequent grinding. The accuracy and character of the work are thus dependent almost entirely upon the excellence of the machine upon which it is performed, and not upon the skill of the individual workman.

The great interest which was displayed in the discussion of grinding processes at the recent convention of the American Society of Mechanical Engineers, and the advantages of modern grinding methods which the discussion elicited, showed that manufacturers are becoming alive to the importance of the grinding machine as a standard tool. The idea that grinding is a special process, to be employed only in a limited number of cases, is being replaced with the knowledge that the grinding machine, in its best types, has become an accepted device for the reduction of parts to their correct form, and this knowledge is rendering the use of the grinder far more general than heretofore. As a labour-saving machine, it is doing much to reduce manufacturing costs, and as an appliance for increasing the accuracy of finished products it is raising the standard of machine work throughout. In addition, it is transferring a large portion of the result formerly dependent upon the skill of the man to the far more controllable machine.

Surface Reduction-Grinding

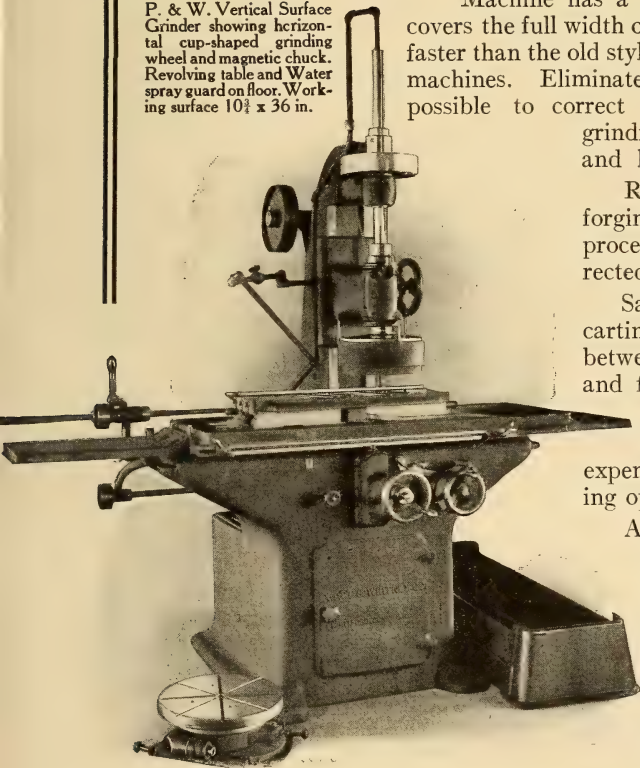
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with all surface milling and shaping operations.

Works 10 to 25 times faster than any previous method known.

P. & W. Vertical Surface Grinder showing horizontal cup-shaped grinding wheel and magnetic chuck. Revolving table and Water spray guard on floor. Working surface 10½ x 36 in.



Machine has a horizontal cup-shaped wheel that covers the full width of the work. Grinds several 100% faster than the old style of vertical wheel surface grinding machines. Eliminates all surface errors that were impossible to correct in milling or in vertical wheel grinding. Works directly on the rough and hardened castings and forgings.

Relieves all apprehension of thin forgings warping during the hardening process, as all such faults can be corrected later by flat surface grinding.

Saves the time ordinarily wasted in carting machine parts back and forth between forging, machining, hardening and finishing departments.

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A long needed machine for producing cheaper, better and more accurate machine parts, tools, hardware and cutlery. Actually reduces cost of manufacture from 25 to 75%.

Built in two sizes.

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A Question of Endurance

IN many of the text-books on machine design much space is given to the subject of the form and proportions of the teeth of gear wheels, and it almost seems as if some writers considered the question of the teeth of wheels the most important subject in the whole department of mechanical engineering. Notwithstanding the amount of matter which has been thus given to the question, it will be found that very few writers pay attention to the material of which the teeth are composed.

Elaborate investigations have been made into the strength of teeth, and the formulas for the resistance of an overhanging beam have been worked over to make them suit the assumptions selected to fit the case of the gear tooth, in order to enable the power-transmitting capacity to be computed, while in very few instances has the question of wear been taken into account. As a matter of fact, the endurance of the teeth of gear wheels is important for more than one reason. Naturally, the life of the wheel is a measure of its efficiency, and the time during which good service is attained should be measured against the cost. Apart from such direct relation between the cost and the period of service, there should be considered the matter of deformation.

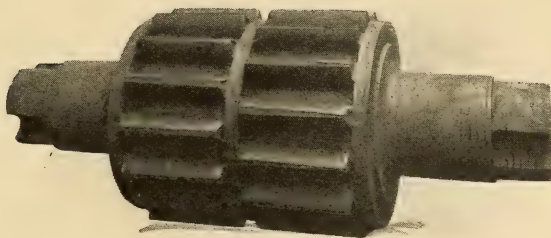
The modern gear wheel represents the latest refinements in the application of geometry to mechanics, and the study of the proper curves for tooth profiles has been supplemented by the production of highly organized machine tools for the precise reproduction of these forms in the actual teeth of the wheel. It is often overlooked, however, that, under the demands of modern intensified manufacturing operations, the wear upon such teeth will make such modifications in their form that, unless the material is of the most resistant character, these curves, so carefully studied and so accurately reproduced, will be gone long be-

fore the operative life of the wheel is over.

The question may well be asked, What is the use of going to such care to secure correct tooth outlines if they are so soon to be disturbed by the deformations under actual work? The inquiry is indeed a pertinent one, and there appears to be no reply of importance other than to admit the necessity of using the most resistant and durable material available, or else concede the foolishness of taking so much trouble about a vanishing detail.

As a matter of fact, engineers have understood very well the importance of using durable material for gear wheels, and the development of machine construction shows the manner in which improved materials have been employed as promptly as they appear. Cast iron was replaced by the steel casting, and the latter gave way to various alloy steels until the final test of practical service should determine which of these possessed the desired staying power. Nickel steel had been considered one of the best of materials for such purposes until the development of vanadium steel revealed the immense capacity of the latter alloy to resist wear.

The only manner in which comparable results can be obtained in such matters is to make the tests under absolutely identical conditions, and in the case of gear teeth we have such an opportunity in the use of twin pinions in rolling-mill service. In this work it has been found that a pinion of vanadium steel produced 100 per cent. more tonnage than the corresponding pinion of nickel steel, the cost of the two pinions being the same. Apart from this remarkable result, it is evident that the teeth of the pinion of greater endurance must have retained their correct form far longer than those which wore more rapidly, so that the efficiency of the power transmission must have been affected in even greater proportion.



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A nickel steel and a Vanadium steel pinion were put in companion service in a 45" Blooming Mill. Both were made at the same time by the same company from the same pattern and sold at the same price.

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Life of Wire Ropes

MANUFACTURERS of wire rope are frequently asked "how long a certain wire rope will last." This is a difficult question to reply to with any degree of satisfaction, because the factors determining the life of a wire rope are so various that it is impossible for anyone to predict with any degree of exactitude what the life of a wire rope will be without knowing the conditions of service for which it is intended, and even then there are elements entering into the matter, such as atmospheric conditions, nature of the water with which it will come in contact, and the care taken of it, upon which no one can base any calculations.

All wire ropes used in outside operations suffer more or less from oxidation or rusting, and wire ropes running underground are frequently subjected to the corroding influence of water containing acids, which is still more destructive; and it is very necessary, therefore, that such ropes should be properly coated with some suitable material. For ropes subjected only to atmospheric conditions, a good quality of boiled linseed oil, or pine tar thinned with turpentine, will answer the purpose; but for ropes coming in contact with water, and especially with water containing acids, some of the preparations of crude petroleum, or a mixture of this with graphite, should be used. A number of compounds expressly prepared for wire ropes are offered by parties making a specialty of such materials. The graphite compounds have been found to adhere well, and, not being easily washed off, they are especially applicable to hoisting ropes in mine shafts.

The factors generally most destructive to wire rope, however, are abrasion and overstrain, due to an excessive degree of bending. The effect of abrasion is to destroy the wires or tear them apart, resulting in a ragged surface of broken wires. The effect of undue bending alone, however, appears in the fracture of the wires

at the crown faces without being displaced. A flattening of the wires to a considerable degree without breaking after considerable service is evidence of legitimate wear. It goes without saying, however, that no wire rope, no matter what the quality may be, will last forever. The effect of bending is to produce a certain tension in the wires, depending on the size of the outer wires and the radius of curvature, and the amount of such stress can be readily determined by calculation, and this is the only factor that can be figured on with any degree of certainty.

Most people do not stop to consider the effect of bending on a wire rope, but seem to think that, like a hemp rope, it is a matter of small account what the size of the sheaves may be. This is a mistake, however, as the stress due to bending very often, and, in fact, generally, exceeds the stress due to the load, and the size of the sheaves, therefore, around which a wire rope runs is a very important factor in determining its life. Ropes composed of larger wires, as a rule, are best adapted to withstand abrasion, whereas those of finer wires are more flexible, and, consequently, are better adapted to running about sheaves of comparatively small diameters. Where wire ropes are subjected to both abrasion and severe bending, it is often a matter to be determined only by experiment just what construction and grade of rope may be best adapted to the purpose; hence it is impossible to say just how long a wire rope will last.

Considerations such as these show the importance of taking the conditions into account for each installation and using the accumulated experience of engineers who have made themselves specialists in the use of wire rope before deciding upon the kind of rope and the size of sheaves. A plant may be copied from another satisfactory one and yet fail to give good results for lack of just such experience.

THE POUND COST OF MACHINERY

By William Hewitt

“DON'T ask what a machine costs per pound, but what will it do per dollar of cost,” may not be one of the proverbs of Job, but it is a good one all the same.

Everyone naturally wishes to get the most for his money; but it is not always weight that counts, especially in the case of machinery. Unless the material is so placed as to withstand the stresses in the various parts, its weight may be not only of no avail, but actually an encumbrance. The value of a cloth is not in its weight alone, but in the quality and texture of the fabric, and so with machines and structures of all kinds; in fact, it is in the design, distribution of parts and quality of the material that we should look for durability and efficiency, and not in the avoirdupois. In the purchase of machinery, structures and economic appliances of any kind, therefore, the chief consideration, should be, not its weight, but what service is to be obtained for the investment. It would be folly to pay for weight in a bridge that might result in overloading the structure.

Consider an aerial tramway, for instance, the equipment for which costs about 10 cents per pound. It is not uncommon for persons contemplating the installation of such lines to remark that they can buy the material for a bridge and surface track equipment at less than half the cost per pound, without stopping to consider that such an installation, although it may serve the same purpose, perhaps, would require four to five times the weight of material and cost to install proportionately more, owing to the grading or other structural work that may be required; so that the first cost of an aerial tramway is in

reality not only cheaper, but such a line can often be operated and maintained with greater economy.

A large portion of the equipment for an aerial tramway consists of wire cables and rope made of high grades of cast-steel wire, and in the construction of the carriers also, consisting of the receptacles for holding the material to be transported, with the accompanying hangers, carriages and grips, especially the latter, the labour cost is high as compared with the cost of the raw material, so that it is manifestly unfair to compare the pound price of such an installation with that of a bridge made of rolled structural shaped bars or a surface railroad, the equipment for which consists mostly of rails upon which the labour cost is comparatively small.

It is an old adage that you cannot make a whistle out of a pig's tail; neither can you get music from common market wire. To make wire that will resound to the touch with a musical twang requires the highest grade of material and the most careful manipulation. To all appearances the two wires may be alike and their weight the same; but, under tension, touch the one, and the labour put upon it responds in harmonious resonance that the other entirely lacks. And so it is with most materials. While the labour may not show upon the surface, it develops in the quality and service rendered; and with machinery the labour is not alone in the work put upon the material, but also in the expenditure of gray matter, that responds equally to the touch, with correspondingly remunerative results. The question, therefore, should be, not what does a machine weigh, but what will it do.

Railway Rates at Home

FOR a number of months the commercial and financial world has been agitated over the proposal to raise freight rates upon the railroads of the United States. The Inter-State Commerce Commission has had the question under consideration, and the railroads and the shippers, represented by able counsel, have been presenting both sides of the case in the form of testimony and argument. When at last the decision was rendered, the industrial world felt that, however individual opinion may have been, a burden had been lifted in the removal of the uncertainty which had been hanging over business, and men knew where they stood in the transportation field.

Without desiring in the least to minimize the importance of stability and moderation in external transportation charges, it may be permitted to call attention to the fact that nearly every one of the shippers who stood out so firmly against increased freight rates was, and is, charging himself with transportation expenses within the walls of his own establishment far more excessive in proportion than any railway would dream of imposing. The counsel for the shippers maintained that the railroads could secure far more money by installing scientific methods of management than they could hope to raise by increase in their charges to the public. He might, with equal force, have told the shippers that they were taxing themselves, by reason of inadequate and inefficient transport methods in their own establishments, as heavily as the railroads were asking to charge outside the walls.

Let any impartial manager make an inspection for himself, or, better yet, engage a specialist to study operations, not casually, but quantitatively, and discover just how much is expended in the course of a year in the transport of material hither and thither from the time that it is delivered on dock or platform in the raw state until it is passed out again

to the railroad as finished product, sold for a price. Find out how much its travels about the shop cost, as compared with the portion of its journey on the railway for which the manufacturer has to pay, and then consider what would be done if the railway ventured to charge such excessive rates for hauling such short distances!

Too often the cost of transport about the works is considered as forming a necessary part of the manufacturing operations. Within certain limits this is undoubtedly true; but when these movements are effected in irregular, expensive and uncertain ways the costs mount up in a wholly unnecessary manner. It has been shown that the most expensive labour in the world is not that of the skilled mechanic, the man who produces value every moment of his work, but rather the ignorant roustabout on the river steamboat, who makes a few violent exertions in the course of the day, moving merchandise a few yards to and fro, and is a non-producer for the balance of the time for which he is paid.

An industrial railway in and through the shop, equipped, when circumstances permit, with electric traction, will displace enough of this high-priced, low-efficiency labour to return ample returns on the investment and pay dividends besides. The inevitable fraction, of which all business consists, may have its value increased in two different ways, either by increasing the numerator, the selling price, or by reducing the denominator, the manufacturing cost. Both are good, when they can both be effected; but too often the former cannot be accomplished when there is abundant opportunity to do the latter. It is foolishness to complain about external railway rates when the excessive transportation rates at home are capable of so great reduction, without asking the permission of any commission or any individual except the one most concerned, the owner himself.

Cut Down Costs—

on the Transportation of Your Materials

Our System of "Industrial" Railways will place material where desired rapidly and economically

Increase Your Profits, Save Your Money

THE cost of transporting material from shop to shop or from one department to another in a factory is a far larger item of expense than is usually supposed. To reduce the expenses and to increase the capacity of the works is a subject worthy of the manager's careful consideration. Few realize the saving made by the use of a narrow-gauge track and suitable cars in handling their raw and finished materials. Suppose a system of tracks in a manufacturing establishment would save the wages of a boy at only 50 cents per day. This saving of \$150 per year would pay 6 per cent. interest on an investment of \$2,500. One can scarcely imagine a place where so large an investment could be made for a system of tracks and cars and no greater saving result.

If we can prove to your satisfaction that one man can, on our "Industrial" Railway, easily handle one ton and maintain this work day in and day out



Do you not think it is worth consideration ?

Write and send us sufficient data and we will make a drawing of the tracks arranged to suit your situation. We will do this for you without charge.

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The Price of Safety

THERE is much agitation at the present time about the subject of accidents to workmen, and many schemes for providing pension funds, accident benefits and free hospital service are being advocated. Most of these are entirely well meant, but based upon considerations wholly aside from the true basis of final satisfaction.

Thus, it has been proposed, in an important department of industry, to place a small additional charge upon the final price of the product, upon the theory that the "ultimate consumer"—the man who pays the last bill and cannot pass the charge along—should provide the pension fund for the men who have been disabled in the service of the manufacturer. In other countries there have been devised various forms of compulsory insurance and benefit funds, controlled and supervised by the government, and imposed either as a tax upon the employers or against the wage of the workman himself, but invariably passed along in the cost of the finished article to the individual who buys it to use and not to sell.

The trouble with all such plans, apart from the bad influence which they exert in taking from the man his personal independence and stimulus to make his own provision for emergencies, lies in the fact that they come into action *after* the event, instead of anticipating it. It does not restore the crippled man to usefulness to give him a meagre pension, nor does it relieve the employer from the loss of the service of a useful operator to know that a clean bed in the hospital is awaiting the injured body. Accidents will happen, according to the ancient saying; but it might well be amended by adding that they happen almost wholly in places which use defective and old-fashioned appliances and keep surprisingly far away from the modern establishment supplied with really high-quality equipment.

There are few things which cost

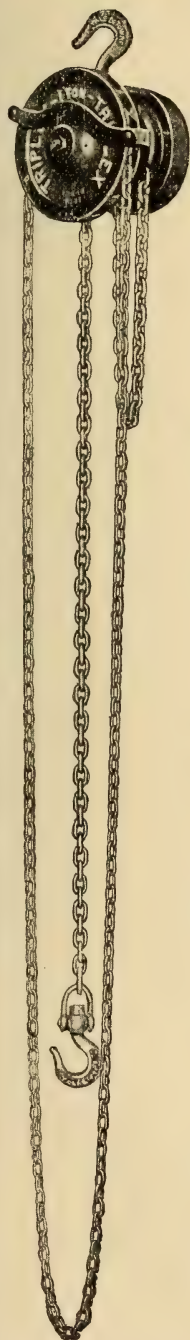
so much as a breakdown; and if we understand by cost the real expenditure for value obtained, the cost becomes infinitely great, because there is no value, but rather a loss incurred. The real way to provide for accidents to employees is based upon another old saying: "An ounce of prevention is worth a pound of cure." That this is also the very cheapest way must be evident. The slight increased cost of a well-made appliance of high quality and correct design and strength over that of the weak and defective one is hardly worthy of consideration; it amounts to far less than accident insurance, and it is distributed over such a great volume of product as to become inappreciable as a charge to the final consumer. The true method of paying the price for safety is no secret to be discovered; it appears in the simple plan of buying and using only such devices as do not permit accidents to occur.

Viewed in this light, it will be seen that the burden of safety rests upon the designer and builder of the machine, as well as upon its owner or user. Various regulations are made and enforced with more or less efficiency in connection with the storage and use of dangerous explosives, and it might well be urged by analogy that dangerous machines should also be placed under the ban.

What is needed is a demand for apparatus with which accidents cannot occur, which will not let the burden fall when the man lets go; which have such ample margin of safety that breakage is unthinkable; which contain the right materials, rightly placed, and are built with honesty, as well as with steel and bronze and iron.

With such tools there will be no need for accident funds, beneficial organizations, and other plans for mending the broken legs and nursing the damaged workmen, and the cost of administration of insurance schemes may be devoted to production instead of human repair work.

THE TRIPLEX BLOCK



Quality! Quality! Quality!

ELEVATORS are insured—inspected. Their safety is constantly watched and guarded.

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CASSIER'S MAGAZINE

Stopping the Power Leaks

ANYONE who, entering a manufacturing establishment, perceives above him a rapidly-revolving shaft, carrying numbers of pulleys, and delivering power by means of belts to many active machines, may take all this smooth-running apparatus as a rather simple and convenient means of power transmission. Nevertheless, it has been found that when any systematic attempt is made to increase the efficiency of a manufacturing plant one of the first things which the skilled engineer usually has to undertake is the rearrangement of the belting, pulleys and power-transmission machinery generally, in order that its losses may be reduced and its capacity increased.

The principal causes of losses in power transmission by belting may be divided between the shafting and the belts and pulleys. Shafting losses are due mainly to excessive friction, generally caused by defective alignment. If shafting is not kept truly in line it will meet with such a great resistance to turning as to absorb more power than it transmits.

It is not difficult to put a section of shafting in line, but in many shops it is almost impossible to *keep* it in line. This is largely because it is continually being disconnected and connected up again, disturbing couplings, hangers and bearings, in order to permit the placing, removal or shifting of pulleys. Each new machine requires its driving pulley to be put on the shaft, and the new pulley may come between two older ones, or in a place demanding a change in position of some previously fixed pulley, or in some position which involves a reorganization of the entire length of shafting where it must go.

Such work is usually done under pressure, often in dark and inconvenient locations, and usually in overtime periods; and, so long as it gets done at all, the question of restoring the original accurate alignment of the shaft is often overlooked. When speeds of existing machines are to

be changed a similar disagreeable job must be done, and the task of putting up the new pulley must be preceded by the removal of the old one, so that the chances of maintenance of correct alignment of the shafting are even more remote.

Losses with pulleys and belts may be traced mainly to slippage or to improper proportions and conditions of belts. Slippage is minimized by the use of proper surfaces on the pulleys, while any attempt to correct the proportions of the belting includes rearrangement of the pulleys as well, followed by all the train of shafting disturbance which has been noted.

In the face of all these entangled problems which meet the engineer who desires to reform an inefficient power-transmission system, it is interesting to perceive how one simple solution appears for each of them. By making the pulley of wood, there is provided a surface for the belt which reduces slippage losses to the lowest point. By making the wooden pulley in two halves, so that it may be placed immediately in any position on the shaft, or removed at will, all occasion for meddling with the correctly aligned shaft disappears. Each pulley is practically independent of every other one, as regards dimensions, position or fastening. The whole cause of trouble—the necessity for slipping a pulley along the shaft—inherent in the solid pulley, is removed.

In addition to the advantages thus afforded for getting over the troubles of the transmission engineer, the wooden pulley relieves the mechanic of the most difficult part of his work in handling. In most cases the light weight of the wooden pulley renders the erection of any scaffolding unnecessary, and the work of installation may be accomplished by the aid of an ordinary ladder and the strength of a few labourers during the noon hour. There are but few instances in the entire history of engineering in which so simple a device has swept away so many obstacles.



"Independence" Wood Split Pulleys Give Better Service—Cost Less

THERE are now over 3,000,000 Dodge Wood Split Pulleys in use in all kinds of industrial plants throughout the world. And the sales are steadily increasing. Nor are reasons hard to find for the widespread adoption of this pulley by manufacturers.

Save 15 to 30% On Your Pulleys

For, in the first place Dodge Wood Pulleys cost 30% less than any type of

And they cost about 15% less than old-metal pulley regularly carried in stock. That is, they cost 30% less than any type of split metal pulleys with interchangeable bushings. fashioned solid iron pulleys, which are good only for the one size shaft for which they were made.

Also, broad experience has demonstrated that these wood pulleys are the most efficient pulleys made for fully 75% of all ordinary pulley requirements.

So, in most shops and factories, the entire first cost of pulleys can be reduced from 15% to 30% if Dodge Wood Split Pulleys are installed in place of metal pulleys.

Gain These Advantages

And consider this. The reduced first cost is on a pulley which—because of its superior wooden belt surface—will transmit more power with the same belt and belt tension, than can any metal pulley.

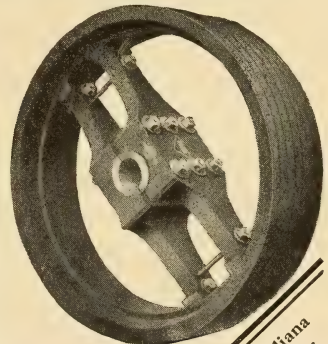
A pulley which may be secured in any locality in from twenty minutes to twenty-four hours time at most (special sizes can be furnished from the factory in three days). And which, being split, can be erected on the shaft quickly and easily, without taking the shaft down or disturbing the bearings, couplings or other equipment.

The pulley may be as readily taken off and fitted to some other shaft by means of the interchangeable bushings.

Investigate Dodge Pulleys for Your Plant

If you will let us send you our bulletin C-77, "From Log to Line Shaft," you may find out some pulley facts which are new to you. And which explain how Dodge Pulleys are made, balanced and tested. How quickly they may be installed. How little they cost. How long they last. And how all regular sizes are carried in stock for immediate delivery, with interchangeable bushings to fit all shaft diameters, by our ten branch houses and more than two hundred selling agents throughout the world.

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Cutting Processes

PERHAPS there are few things commonly done and generically described by a single word which can differ in character so widely and so essentially as do the various cutting devices and operations employed in the industrial arts and elsewhere. The typical cutting, and what the word first suggests, is that which is done with a sharp knife. The perfection of simplicity and ease in cutting is when we can say of anything that it cuts like cheese.

Next to the knife, and not very near it in kind, is the saw. The wedge action of the knife is here abandoned at once, and the teeth of the saw tear and drag the material. The cutting of the grindstone and the emery wheel is almost pure abrasion, so that the wear of journals and slides is a kind of cutting as far as it goes, and when the surfaces become dry and the abrasion is rapid cutting is the word we use for it. A cold chisel driven by a hammer has something of a wedge-like action when cutting soft steel or other tenacious metal, but when it gets to cast iron it rather breaks than pushes the material away; in cutting stone the breaking of the material is more pronounced, and still we call it cutting. Then comes the percussion rock drill, which could never cut stone as a knife cuts, but still works its way rapidly into the rock by its crumbling or pulverizing of the material.

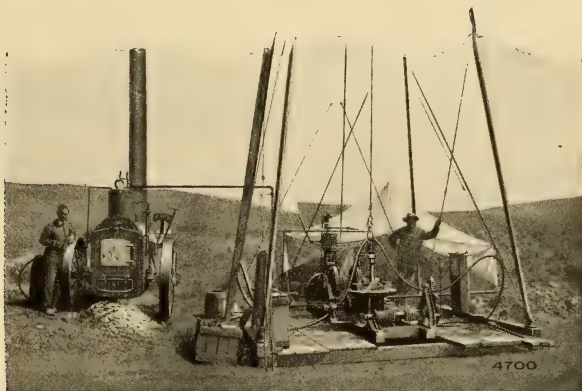
All these ways and means of cutting have their special lines of employment, and in these lines neither could take the place of the other. The rotating twist drill would be worthless in a granite quarry, and the percussion rock drill could not penetrate steel plates or shape the surfaces of castings to precise dimensions in the machine shop. The different processes and apparatus have developed and have found their different employments in obedience to specific demands.

Perhaps nothing ever appeared more clearly responsive to an actual and well defined need of the worker than did the core drill. It is the earth sampler or taster, and tells the planner of great works, which will involve the cutting away of masses of rock and the penetrating to unfamiliar depths, what material will be encountered, so that he may make calculations and preparations in advance. It also tells the seeker for veins and beds of valuable minerals to be mined where he would waste his labour by penetrating and where he might be richly rewarded.

It is a curious thing that, to meet and satisfy this new requirement, we find cutting instruments and cutting processes still different from any of those above enumerated. The cutting of the diamond drill may best be characterized as a scraping action. The surface is scratched and the material is dragged away, being finely comminuted by the process of removal, so the result is the same.

The action of the shot in the Calyx drill, the successful and established rival of the diamond drill, would, at first, seem simple and evident enough. The individual shot, of course, become rollers, and as they pass over the surface, each bearing only upon a minute portion at a time, they crush or disintegrate by the rolling pressure and the water washes the stuff away. This would seem to be very far from explaining the action when cutting through iron and steel, and we do not here attempt an explanation. Tools, like men, are judged ultimately by their record, and the records in this case not only of actual accomplishment, but of the cost of it, are indisputable. The records of the comparative costs of the cutting or abrasive or crushing elements, whichever we may choose to call them, give the "shot" drill a vast advantage, especially in the production of cores of such diameters as would be prohibitive by any other means practically available.

"CALYX" DIAMONDLESS Core Drills



CORE DRILL SECURITY

When a mine owner, quarryman, or contractor is sufficiently interested in the ground underlying his work to wish to explore it by core borings, he wants the maximum assurance that true records will be returned.

The "Calyx" Diamondless Core Drill gives him this assurance. For its large cores—larger than any diamond drill can give, even at many times the cost—leave no room for doubt as to the material penetrated.

A firm, solid core, $2\frac{5}{8}$ inches in diameter and larger up to 20 inches, is the record which a "Calyx" Drill shows.

Coupled with this feature of reliability are an economy of operation, moderate first cost and simplicity of construction which mean low core drilling costs.

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CASSIER'S MAGAZINE

Insurance Against War

THE old-time armourer was the skilled mechanic of his day, and the visitor to the art museum who examines the suits of mail and the beautifully chased and inlaid work, both upon armour and weapon, is compelled to express his admiration, both of the artistic design and the manual skill which produced such articles.

To-day much of the skill which was formerly possessed by the individual has been transferred to the machine. Leaving aside for the moment the subject of armour, which has been shifted from the soldier to the warship, the manufacture of ordnance now represents one of the most widely extended fields for the employment of machine tools of the highest grade and greatest variety.

When it is considered that modern ordnance covers the wide scope included between the rapid-fire gun of less than 1-inch bore and the great 16-inch disappearing coast-gun, and that its accessories involve the construction of carriages, with mechanism for controlling recoil and for elevation, adjustment, range-finding and sighting, it will be seen that the equipment of an arsenal of to-day represents nearly every product of the machine-tool builder's art.

Notwithstanding the wide range of machinery thus demanded in the production of modern ordnance, it is found that maximum efficiency and highest perfection in results require the design and production of various special tools, these being in large measure the evolution of experience in the actual productive work, and enabling reduction in the number of operations required, while at the same time increasing the efficiency of those remaining to be performed.

At the present time much is being said and written about the importance of maintaining a high degree of efficiency in the workman, but it is not always realized to what extent the efficiency of the mechanic is bound up with that of the machine

with which he is connected. There is probably no more effective method for increasing the efficiency of a workman than by transferring as large a part of the skilled work as possible to the machine, thus enabling mechanics of very moderate ability and cost to produce results fully equal to those which, with the ordinary tools, would have demanded the attention of more skillful operators.

This is especially true of such products as those of the arsenal, in which accuracy, interchangeability and high precision are essential. Hand fitting may be wholly dispensed with by the use of gauges, jigs and special fixtures, while the quantity of product is increased and the cost lowered.

An examination of the leading arsenals of the world will reveal the extent to which the latest types of machine tools, both standard and special, have been installed for the production of modern ordnance, and it will also reveal the fact that these tools represent in great part the product of an American organization which has been foremost in the development of this work.

Lord Nelson maintained that a nation's first line of defense was the enemy's coast, and, conversely, it follows that coast defense should be the foremost element in the maintenance of that peace which follows an adequate protection to a people against any possible enemy. It is now well understood that peace between nations, like peace between individuals, can be best maintained by proper police protection, and when military expenditures are regarded in this light the engineer, the tool builder and the mechanic in the arsenal may be considered foremost among the men who are helping to usher in the time of peace between all nations. Behind the coast which is defended by the best products of the mechanical engineer the people may pursue their avocations in safety and security, and the cost of such defense may well be considered as insurance of the highest class.

ARSENAL EQUIPMENTS

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For Field, Battleship and Coast Defense

Covering every machine tool required for the construction of any type of gun from the smallest automatic to a 16-inch disappearing coast gun. Also machine tools for manufacturing any kind of ammunition, including projectiles, casings, fuses, etc.

Special machine tools that represent a line of exclusive designs, which greatly reduce the number of operations, assure accurate duplication of parts and that permit a major part of the work to be performed by unskilled labor.

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Separate or combination machines for turning or boring a completely assembled gun, or the various parts before they are assembled, such as tubes, jackets, hoops, etc.

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HEAVY MACHINE TOOLS

For boring, milling, drilling and tapping operations on breech mechanisms, recoil cylinders and gun-mounts of all types.

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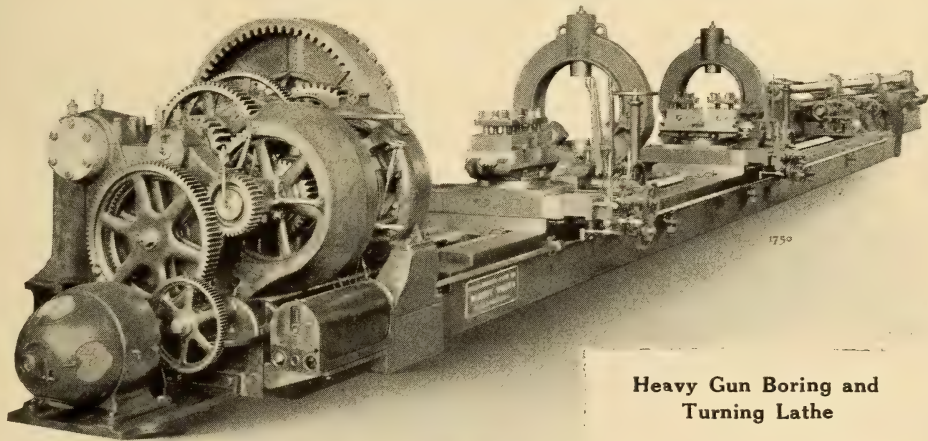
Comprising a line of detail machinery such as milling machines, profilers, spline millers, grinding machines, multiple drills, thread millers, bench lathes, etc., etc., for producing accurate detail work of the highest order, especially on such work as sights, range finders, and similar precise details.

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The Niles-Bement-Pond Company has equipped the majority of the leading arsenals of the world—their machine tools being represented in nearly every important gun factory either wholly or in part

Correspondence is invited with Gun Factory and Arsenal Officials on any line of machine tool equipment for heavy ordnance and small arms manufacture.



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Grinding Out Money

MEN are beginning to understand that the real thing which gives value to money lies in the results which can be accomplished by its use. The printing press may print bank notes, and the coining press may mint gold and silver; but it is the continual operations of active industry which give these things the value which they possess, and, when cast ashore upon the desert island of Robinson Crusoe, they are laid aside as valueless.

There are other metals besides gold, however, which need only to be set to work to produce real value, and the actual coining presses of to-day—the machines which are really grinding out money—are using iron and steel, and produce things which go to form our buildings, railways, steamships and workshops—things which again create new values which otherwise would never have existed at all.

One of the most powerful machines which thus grinds out real value is the modern rolling mill, and the products which come from its operation depend for their existence upon the effectiveness and continuity of its work.

Under such conditions the amount of money which it can produce depends directly upon its strength and endurance, upon the stuff of which it is made itself. Every moment that the mill is idle is that much reduction of its productiveness, and if the machine may be so made as to have a life of double length the real value is proportionally increased.

Realizing these facts, the designing engineer is prompt to adopt as materials of construction the latest and most effective substances which applied science has placed at his disposal. Steel has replaced iron; alloy steels have, for many purposes, replaced carbon steels, and the work of the chemist and metallurgist has thus produced from the crucible a result far surpassing that of the fabled philosopher's stone. The only re-

sult which could have followed the discovery of any method of making gold would have been such a rapid depreciation of its value as to have destroyed its own purpose. The results which have proceeded from the isolation and utilization of such elements as vanadium, for example, are seen in increased value to both materials and machines of which they are made.

Thus, for no greater cost, nickel steel may be replaced by vanadium steel in the casting of the heavy pinions upon the performance of which the action of the rolling mill depends, and the capacity for wear is doubled. The presence of the vanadium increases both the ultimate tensile strength and the toughness of the steel casting, and hence, in addition to the doubled life against wear, the probability of interruption by breakage is made extremely remote. The capacity of the rolling mill to create value is thus practically insured without the payment of any insurance premium, and the continuity of its productivity is assured.

In this connection it should also be remembered that modern rolling-mill equipment is so arranged that any interruption to the operation of one important element delays many others, and that the loss due to any breakdown is not limited to the particular part which has failed.

The great point to be considered in connection with the new wealth which is thus added to the world's stock by the utilization of substances once considered as curious rarities lies in the fact that the results are of continuously increasing importance. While a flood of new gold would result only in an alteration of values and rearrangement of equivalents, the increase in production of materials of construction, such as beams, girders and rails, acts as an impetus to all other departments of industry. The real philosopher's stone is here, creating new values daily, values which are lasting and active, not temporary and inert.

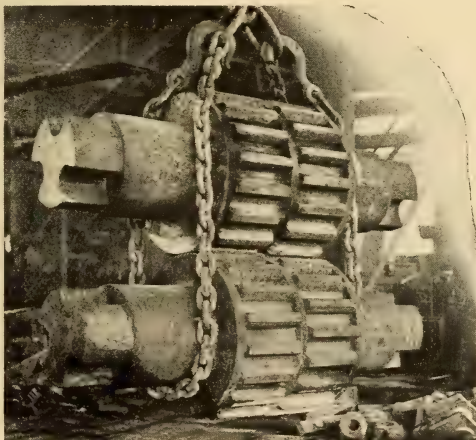
Vanadium Cast Steel Pinions

**Cost the Same and Work Twice as
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Figure it either way: on the basis of cost you save one half; on the basis of production you get twice as much, to say nothing of time and money lost in the operation of replacement.

Repeat orders are the final proof that users of large pinions fully appreciate the efficiency and economy of always specifying Vanadium Cast Steel pinions in all classes of severe work.

These pinions for a 34-inch Blooming Mill were made by the Union Steel Casting Company of Pittsburgh, from "Amervan" Ferro Vanadium supplied by us. Tensile strength 112,010 lbs. per square inch; elastic limit 63,180 lbs. per square inch. Wearing efficiency over nickel steel, 100%. Cost on service secured, 50%. All good steel foundries use "Amervan" Ferro Vanadium when economy and efficiency are required in castings. Study this out and write us for illuminating figures.



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Automobile Engines

BUILDERS of engines for automobiles have had to work out the fundamental elements of their designs in a manner similar to that which the early steam-engine makers had to follow. The theoretical principles furnished excellent guides for general purposes, but the actual operative conditions could make themselves felt only in the course of time. The first automobiles were equipped with motors which had their origin in the gas engines designed for stationary service, the modifications being mainly in such increase in rotative speed as would permit the necessary power to be obtained from an engine small and light enough to be carried on a vehicle. When we consider the entire absence of road experience of these early builders it is remarkable that the machines which they constructed did so well; and anyone who realizes that the entire success of modern aviation is due to the production of a high-power, light-weight engine by the automobile builder will be impressed by the commercial and social revolution which has followed.

It is now beginning to be understood, however, that in their desire to reduce dimensions and weight the designers of the ordinary engine for automobile service may have gone too far. The power given to the piston undoubtedly depends upon the force of the explosion and upon the area of the piston, but it also depends upon the velocity in feet per minute which that piston maintains. The number of feet per minute is governed by the number of revolutions made by the crank, and also by the length of stroke of the piston in the cylinder.

It is this last element—the length of stroke—which is now attracting attention among automobile engineers, and there is every reason to believe that an increase in length of stroke over that ordinarily adopted will prove a distinct advantage. If an engine has a stroke of 4 inches

the piston will travel 66 feet for every hundred revolutions, while if the stroke is 6 inches long the travel for a hundred revolutions will be 100 feet, or 50 per cent. more. For the same mean pressure this would mean a corresponding increase in power, with no increase in stresses, with greater opportunity for expansion of the gases, with no increase in rotative speed, and with but a trifling increase in weight.

Apart from these gains there are certain operative advantages which may be secured with the longer stroke. For a compression chamber of the same volume the longer stroke permits a higher degree of compression, giving higher efficiency in the engine and no increase in radiating surface of compression chamber. There is also a material reduction in friction losses with the longer stroke and better proportioned crank, the thrust upon bearings being better distributed, and neither surface pressure nor rubbing speed being increased for the increased power obtained. Of course, the advantages of longer strokes are gained only within reasonable limits, and any modification in design of an existing engine along these lines should be made only in connection with a careful technical study of all the conditions entering into the problem.

When we consider the excellent work which is continually being done by the powerful little engines upon the thousands of automobiles in operation all over the world, it is a tribute both to the skill of the designers and the excellence of the workmanship which have been expended upon them. In this respect the designers of stationary gas engines have fallen behind, since the large internal-combustion engines of the present date are far larger, heavier and more costly per unit of power than the small ones; whereas, according to the general analogy of other departments of construction, the advantage should have been with the larger units.



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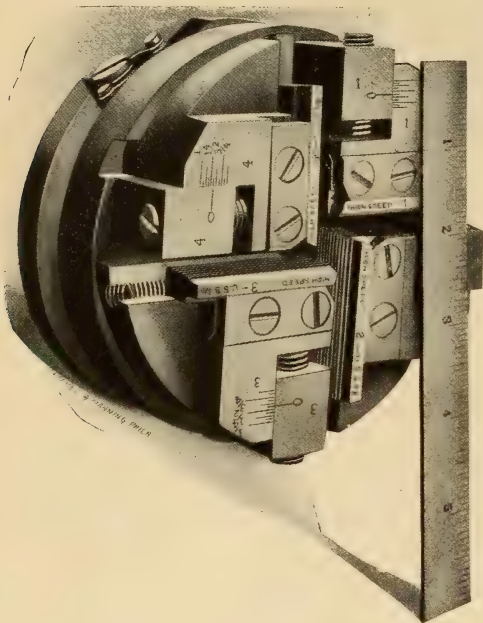
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Solid Adjustable Die Heads

THE purpose of this new die head is to take the place of the solid dies now used on any of the screw machines and other types of machines wherein the work is backed out of the die after the thread is cut.



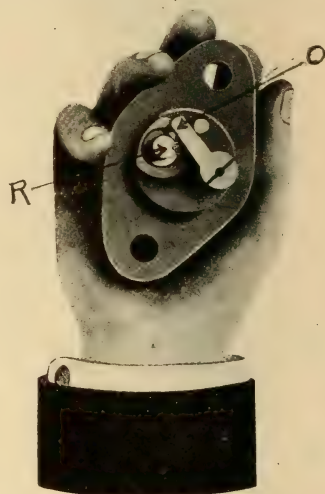
The die head is illustrated herewith, showing the 1-inch standard size, which has a range of from $\frac{1}{4}$ inch to 1 inch. It embodies the use of the long-life, high-speed, free-cutting Landis die, with a very wide adjustment.

The dies are adjusted to and from the centre on radial lines for different sizes, and are held rigidly in their seats.

The die head is held in the turret of any ordinary screw machine, and trips off by retarding the forward movement of the carriage. It is also made without the tripping device for special requirements. The tripping arrangement is so arranged that when the desired length of thread is cut the die head will trip and revolve with the work until the machine has time to reverse.

By using this die very high cutting speeds are readily acquired, equal to the turning and drilling speeds on the other operations of the screw machine, so that the speeds need not be reduced in the threading operation for the accommodation of the die, as is the case with the solid dies.

Chasers can at all times be ground to suit the material to be cut; any amount of rake can be given that is necessary, thereby insuring the best possible cutting condition and securing ideal results.



STYLE OF CHASER USED

The dies are made from high-speed steel and can be ground and reground many times, thus giving a life many times greater than any other solid die, besides never requiring to be annealed, hobbed or retempered, and are readily adjustable to take up wear in addition to the adjustment for different diameters.

One set of chasers can readily be set above or below their rated diameter. For instance, $\frac{1}{2}$ -inch (13-thread) can be set to cut 1 inch diameter, when desired, or they can also be set to cut $\frac{1}{4}$ -inch diameter. The angle in the thread, however, will not be quite ideal, but all that is required for ordinary screw machine work. With other types of die

heads a special set of chasers is required each time you wish to cut other than standard pitches. With this head any diameter within the range of the head can be cut with one set of dies, so long as the pitch is the same. In very special cases where absolutely correct pitch is required, it would be advisable to use special holders, so as to set the chasers on the exact angle to correspond with the angle of the thread. Ordinarily this is not required.

These heads can be supplied in standard sizes with shanks suitable for holders in ordinary screw machines. The $\frac{1}{2}$ -inch head is $2\frac{3}{4}$ inches in diameter, capable of cutting a thread $1\frac{1}{2}$ inches long. The 1-inch head is $4\frac{5}{8}$ inches in diameter, capable of cutting a thread $2\frac{1}{2}$ inches long. Other sizes with special shanks will be made to order.

The dies will regularly be made from high-speed steel. In no other type of die can high-speed steel be used to the same advantage as can be used in this die, as will be readily apparent on the face of same.

This head is manufactured by the Landis Machine Company, Waynesboro, Pa.

Food for Reflection

Trade disputes during 1910, causing a stoppage of work in the United Kingdom and originating in that year, numbered 506, and affected 508,538 working people.

The aggregate duration of all disputes in progress during the year was nearly 9,725,000 working days, the coal mining industry being responsible for the greatest number of disputes, the largest number of workers involved, and the longest aggregate duration; the engineering and ship-building trades followed.

The work people involved in disputes amounted to 5 per cent. of the total industrial population of the United Kingdom, while the amount of time lost represented nearly one working day for each member of the industrial population.

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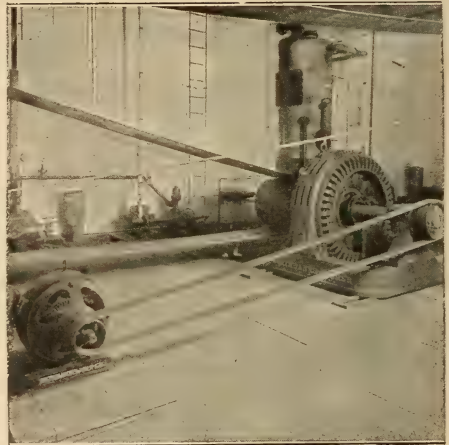
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See large advertisement on another page of
this magazine

Electric Plant of Kingfalfa Mills, Nebraska City, Neb.

THE extensive use of alfalfa meal for stock feeding in our Western States has caused a very rapid growth of a new industry—namely, the grinding of alfalfa stalks for the production of this highly nutritious product.

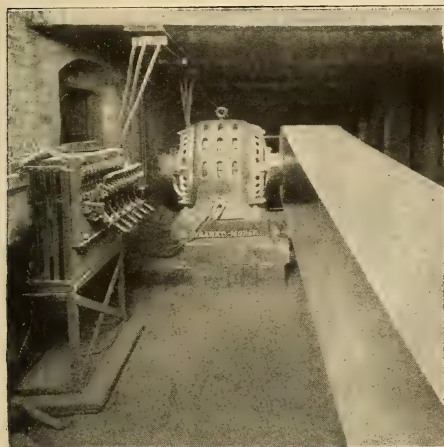
The mills are usually electrically driven, and they form an attractive example of the way in which electric power contributes to the development of a new industry.



A typical installation is that of the Kingfalfa Mills, at Nebraska City, Neb. Their plant consists of a 300-K. V. A., 440-volt, 600 R. P. M., 3-phase, 60-cycle, alternating-current generator of the two-bearing, belt-driven type. This is driven by a 300 horse-power, simple, non-condensing Corliss engine, and the power developed is used to drive a disintegrator, or alfalfa meal mill, and other auxiliary machines, such as blower, dust-collector, packer, etc. The alfalfa mill is driven by a 150 horse-power, slip-ring type motor, which is belted direct to the mill.

On account of the great weight of the mill and the inertia of the moving parts, a high starting torque is required to start and bring it up to speed, which is a severe test on the capacity of both the motor and generating plant.

The main motor drive and the generating plant are shown in the accompanying illustrations. Other motors will be used to operate the auxiliary machinery.



The entire electrical equipment was manufactured and installed by Fairbanks, Morse & Co., through their branch office at Omaha, Neb.

Inquiries to Consular Officers

It is suggested that manufacturers, when sending circular letters of inquiry to consuls, could reduce the work which the answering of these inquiries involves by stating in each letter that a similar inquiry had been addressed to all consuls or to a certain group of consuls, as the case may be.

By way of illustration, an inquiry received at the office of the U. S. Consul-General, Canton, China, relates to certain articles of export manufactured or produced only at the northern ports of China. A copy of this inquiry is forwarded by that consulate to the seven American consulates in the north, and more often than not the reply is made that each of them has already received the same inquiry directly. Had the inquirer indicated in some way that all the consuls in China had been similarly addressed, the writing of fourteen unnecessary letters would have been avoided.

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FINANCIAL NOTES OF THE INDUSTRIAL WORLD

Hydraulic Forging Presses

The United Engineering & Foundry Company, of Pittsburg, Pa., shipped on March 4, to the Westinghouse Electric & Manufacturing Company, of East Pittsburg, Pa., one of their high-speed steam-hydraulic forging presses.

The Westinghouse Company had purchased a 7-ton steam hammer; but, on investigating the forging press, they decided in its favour, and for this reason will not set up the hammer.

The Westinghouse Company found that, to maintain the high standard attained by their goods, it was absolutely necessary to obtain a better class of forged material.

American Locomotives in South Africa

Consul Edwin N. Gunsaulus, of Johannesburg, states that American locomotives are having a large sale in South Africa, where upward of fifty different types are in use, and tenders were recently asked for thirty-five more of United States manufacture.

\$15,000,000 to be Expended in Hydraulic Work by Chile

It is reported from Santiago, Chile, that the Government contemplates extensive hydraulic engineering work at the ports of Valparaiso and San Antonio, and that tenders for the work have been invited. The bids are to be opened at the end of July, and it is estimated that an expenditure in the neighbourhood of \$15,000,000 will be required.

Without doubt American engineers and manufacturing concerns will avail themselves of this opportunity.

Recent Orders

The Westinghouse Electric & Manufacturing Company recently received the contract for sixty-five direct-current series metallic flame, 6.6-ampere lamps and one 65-light, with control panel, to be used in lighting the International Exposition of Industry and Labour at Turin, Italy.

Demand for Gas-Producer Engines in Mexico

Mr. Wilbert L. Benney, U. S. A. Consul at San Luis Potosi, Mexico, writes that there is a growing market in his district for gas-producer engines, and that the field is at present being cultivated with more assiduity by European manufacturers than by American.

As this type of power is available where small plants are desired at isolated points, and where economy is of vital importance, it is especially adapted for this district, where fuel is expensive and where the saving of water is also a factor. Mr. Benney states that these plants are coming into use for pumping, ice-making, small electric plants, milling and general manufacturing, and are replacing small steam engines, as it is estimated that, due to local conditions, a suction gas engine costing, say, \$7,500 gold, can be run at a saving over steam power which will pay its first cost in less than two years.

American Railway Cars for Argentine

The American Car & Foundry Company has been awarded a contract for twenty-one sleeping cars and baggage cars and parts, amounting to \$270,271, by the Argentine Government. This order was secured through their bid made in competition with many other firms.

The Richardson-Phenix Company Open New Office in Pittsburg, Pa.

Owing to their constantly increasing business, the Richardson-Phenix Company, of Milwaukee, have opened a branch office in the Keystone Building, 324 Fourth avenue, Pittsburg, Pa., under the management of Mr. H. N. Laughlin.



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Deposits.....	2,211,900.00
Total Resources.....	2,605,000.00

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The Determination of the Heating Value of Gas

To those interested in the accurate determination of the heating value of artificial gas, which is one of the important problems in the gas business of to-day, of particular interest will be the booklet issued by the Improved Equipment Company, 60 Wall street, New York, which describes very fully the Doherty gas calorimeter.

A few of the principal advantages of this instrument are its simplicity, freedom of all wearing parts which may lose adjustment or get out of order, its compactness, the ingenious means provided for completely draining the instrument, the wide range of its thermometer, and its accuracy, means being provided for the determination of both gross and net heating effect of the gas under test.

"American Vanadium Facts"—A New Publication

There has just come to our desk a copy of "Amervan Vanadium Facts," No. 1, Volume I., for March, 1911.

This is a new periodical issued in the interests of "Amervan Ferro-Vanadium," and is very fully illustrated.

The leading article is entitled "What is Vanadium?" and goes into the subject of its chemical elements.

The other articles on "Vanadium Steel Forgings," "Vanadium Steel Governor Pins" and "Vanadium Steel Castings" are of interest.

The same number reprints the article, "A Question of Endurance," by Mr. Henry Harrison Suplee, which appeared in the March number of this magazine.

An indication of the wide use of vanadium iron and steel is given by a list showing nearly ninety well-known firms who use this "Master Alloy." Among the firms mentioned we note such well-known ones as the Wyman-Gordon Company, the Carnegie Steel Company, the American Steel & Wire Company, the Mesta Machine Company and the United Engineering & Foundry Company.

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Boston Exhibition Retail Coal Dealers Association

At the exhibition of the Retail Coal Dealers' Association, at Boston, Mass., an exhibit that attracted much attention was that of the C. W. Hunt Company, whose coal-handling machinery is so favourably known and widely used.

Foreign Imitation of American Machinery

About five years ago a soap and oil factory at Acapulco, Mexico, put in a new machine for expressing oil. The machine was built in Cleveland, Ohio, and is described by the manufacturers in their catalogue as the "oil expeller." The machine has proved highly satisfactory in every respect, so much so that the proprietor recently decided to put in two more machines; but, instead of buying the identical outfit from the Cleveland factory, as might have been expected from the satisfaction obtained from the former purchase, the new machines, to be copies of the American machine, have been contracted for in Europe. It is also the understanding that the foreign factory has offered to furnish the imitation machines at a price much below that asked by the American factory.

Students Demand to be Shown Proofs of Statements

"It is a marked characteristic of to-day's education, especially in technical colleges, that students demand to be shown the proofs of statements made in the class room, that they desire to see things themselves, to handle them, and to use them in proving the truth of what they have been taught." The above is taken from the Foreword of the number of the Bulletin of Purdue University which is devoted to "Shops and Engineering Laboratories," recently received. It is a most attractive pamphlet, printed on tinted paper with white margins, and illustrated with over twenty-five half-tones of exterior and interior views of the

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Railway Appliances Exhibition, Chicago, Ill.

The C. W. Hunt Company had an extensive exhibition of their well-known products at the Exhibition of Railway Appliances, held at Chicago, commencing March 22.

Meeting National Association of Cotton Manufacturers

The ninetieth meeting of the National Association of Cotton Manufacturers is to be held at the Massachusetts Institute of Technology, Boston, Mass., April 12 to 13. Mr. C. J. H. Woodbury, Secretary and Treasurer, P. O. Box 3672, Boston, Mass.

Trade Catalogues Desired by Wilmington Free Library

A special effort has been made on the part of the Wilmington Institute Free Library, Wilmington, Del., to develop its department of applied science. This effort has been crowned with success, as indicated by the fact that the circulation of technical books used by the working men of Wilmington has increased nearly 200 per cent. in the past five years.

Appreciating the great value of a library of trade catalogues of the various manufacturing concerns throughout the country, the Wilmington Library has recently started such a collection.

Their plan is to have these catalogues so arranged that they will be accessible, and they intend to make this collection as complete as possible. With this object in view, the invitation is extended to manufacturers throughout the United States to send them their catalogues, as any catalogue published in this country will prove of value to them.

Further information may be obtained by addressing Mr. Arthur L. Bailey, Librarian.



Mr. Charles H. Tindale

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THE LATEST CATALOGUES

Feeder Voltage Regulators

The General Electric Company has just issued a revised bulletin, No. 4,791, which supersedes its previous bulletins on this subject, "Feeder Voltage Regulators." The bulletin describes the company's regulators of the induction type and switch type, single and polyphase, hand-operated and automatically operated. It contains connection and dimension diagrams, together with weights of the various regulators described.

Insulating Materials

The Westinghouse Electric & Manufacturing Company has just issued Sections 804, 805 and 806 of its detail catalogue. The new sections describe the complete line of insulating materials recently placed upon the market by this company. The lines described include treated and untreated cloths and papers for insulating purposes, and insulating and soldering fluid, including shellacs, varnishes, soldering acids, soldering paste, glue, cement, etc. They have also issued a catalogue section on their Type S and SA distributing transformers for light and power service up to 3,800 volts.

Drum Controllers for Industrial Service

The General Electric Company has recently issued a new bulletin, No. 4,811, describing its drum controllers. This bulletin contains descriptive matter and data in considerable detail, and supersedes the company's previous bulletin on this subject.

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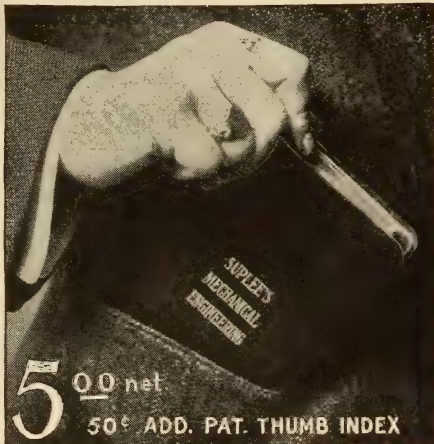
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Catechism on Direct Current Apparatus

Under the above title Fairbanks, Morse & Co., Chicago, have published a very interesting booklet giving, in simple language, definitions for electrical terms and describing the construction and uses of different electrical machines. As the title indicates, this treatise is prepared in the form of a series of questions and answers. It was originally prepared for the use of salesmen only, but there has been a considerable demand for it by others. The booklet is well illustrated and printed on enameled paper. The insight which it gives to the products of Fairbanks, Morse & Co. makes it very interesting to engineers, and, to one who is not familiar with electrical machinery, this pamphlet will be of great assistance. It will be sent on request to interested parties.

The Insulator Book

The above is the title of a very attractive book just issued by the Locke Insulator Manufacturing Company, Victor, N. Y., containing valuable information pertaining to pole and tower line construction, wire, line protective devices, etc. A system has been arranged by them whereby they are enabled to send out their catalogues revised up to the date of mailing, thus assuring the recipient of their very latest information. A copy of this book, No. 92,010, will be sent to those who write for it.

High-Tension Magnetos

A new pamphlet describing the Mea high-tension magneto and giving some interesting details concerning their construction is at hand from Marburg Brothers, Inc., Broadway and Fifty-eighth street, New York. This magneto has proved of valuable service for both automobiles and aeroplanes, having driven both in contests where existing records were broken.

Combination Tool-Room Furnace

Bulletin R, issued by the Rockwell Furnace Company, 26 Cortlandt street, New York, describes their tool-room furnace, which uses gas fuel only, and combines in one the following types: oven, muffle, small forge, lead tempering, cylindrical, end heading, carbon steel and high-speed steel furnaces, and has proved very successful for accurately treating small tools, etc., for annealing, hardening, tempering and forging. This furnace requires very small floor space—16" x 16"—and is so designed that working temperature can be obtained in eight minutes, starting cold. A copy of the bulletin can be obtained on request.

Elevator Controllers

The Cutler-Hammer Company, Milwaukee, Wis., have issued a booklet of 128 pages describing, by text and illustrations, their elevator controllers, and also a booklet of the electric elevator controllers originally developed by the J. L. Schureman Company, of Chicago, which the Cutler-Hammer Company now manufacture. The Schureman type of controllers has for many years enjoyed a high reputation among elevator experts. Copies of their books can be obtained by addressing the Cutler-Hammer Company.

The Pedestal Pile

A book for engineers, architects, owners and contractors, describing the pedestal concrete pile and discussing the relative merits of wooden and concrete piles of various types, has been received from the MacArthur Concrete Pile & Foundation Company, of 11 Pine street, New York.

It is claimed that this pile is a distinct advance in concrete pile construction, and the work takes up the entire subject of concrete piling in an interesting and instructive manner.

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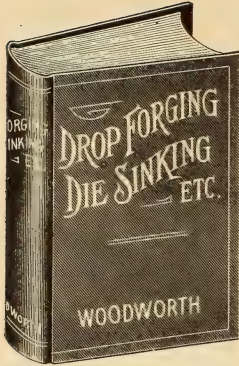
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BOOK NOTES

"Compressed Air in all Its Applications," by Gardner D. Hiscox. This work assembles more tables, formulas and information concerning compressed air than have been gathered together before. It is a valuable treatise on the subject, and the large number of examples worked out to illustrate calculations constitute its most important feature. It is the most complete work that has yet appeared on the subject. Published by the Norman W. Henley Publishing Company, 132 Nassau street, New York.

"Freight-Train Resistance: Its Relation to Car Weight," by Edward C. Schmidt, has just been issued as Bulletin No. 43 of the Engineering Experiment Station of the University of Illinois.

This bulletin presents the results of tests made upon thirty-two freight trains in regular service, in order to determine their train resistance. These tests were undertaken to study the effects upon train resistance of both speed and the average weight of the cars composing the train.

The results show the usually accepted influence of speed upon resistance, and they reveal a still greater influence of average car weight in effecting changes in resistance.

For trains composed of cars weighing 15 tons on the average, the resistance is shown to vary from $7\frac{1}{2}$ pounds per ton at 5 miles per hour to $13\frac{1}{2}$ pounds per ton at 40 miles per hour; while for trains composed of cars weighing 75 tons, the resistance is shown to vary from 3 pounds per ton at 5 miles per hour to $5\frac{1}{2}$ pounds per ton at 40 miles per hour.

It is upon data derived from such practical and scientific investigations that railroad engineers may gather most valuable information in the conduct of their work.

Copies of Bulletin No. 43 may be obtained gratis upon application to W. F. M. Goss, Director of the Engineering Experiment Station, University of Illinois, Urbana, Ill.

Accident Prevention and Relief

An investigation of the subject in Europe, with special attention to England and Germany, together with recommendations for action in the United States of America; by F. C. Schwedtman and James A. Emery; 400 pp., 100 pp. illustrations; de luxe edition, half morocco, \$15; cloth, \$10. Published by the National Manufacturers Company, 30 Church street, New York.

In this comprehensive volume, prepared in harmony with the resolutions of the National Association of Manufacturers to the effect that an equitable, mutually contributory indemnity system, automatically providing relief for victims of industrial accidents and dependents, is required to reduce waste, litigation and friction, also that prevention of accidents is of even greater importance than equitable compensation of injured workers, are embodied the results of the investigations of Messrs. Schwedtman and Emery, special commissioners appointed by the association to study existing systems abroad.

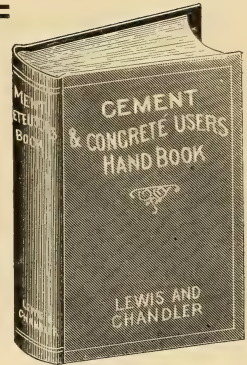
The volume deals exclusively with accident prevention and accident relief for injured workers and their dependents, and as it was found that the methods of Germany and England contain practically all the principles and experience which are required for the building up of a sound system in the United States, the work describes with much care the regulations of these two countries, throwing such light upon various other national systems as seems necessary to convey a complete understanding of the whole subject.

The conclusions and recommendations of the volume go far to establish it as an authority wherever action toward accident prevention and relief is proposed. One of these is "that the waste, delay, and harmful bitterness engendered by litigating claims for personal injury in a legal system based upon fault as the sole ground of recovery justify and require that the State, in the public interest, make other equitable provision for the speedy adjustment of such controversies."

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The reception accorded "Accident Prevention and Relief," just described, wherever advance sheets of the work have been seen, is significant of the scope of the volume and measure of its helpfulness toward industrial progress. A typical expression of opinion is that of Mr. Melville W. Mix, president Dodge Manufacturing Company, who writes as follows:

"Waste and lost motion must be eliminated, and to that end the work of the committee is most impressive and convincing as indicating a wider field to be covered than that so far sought in this country. I hope the report will be heard in every State where such legislation is under consideration, and that every employer, employee and legislator may procure a copy of the printed report."

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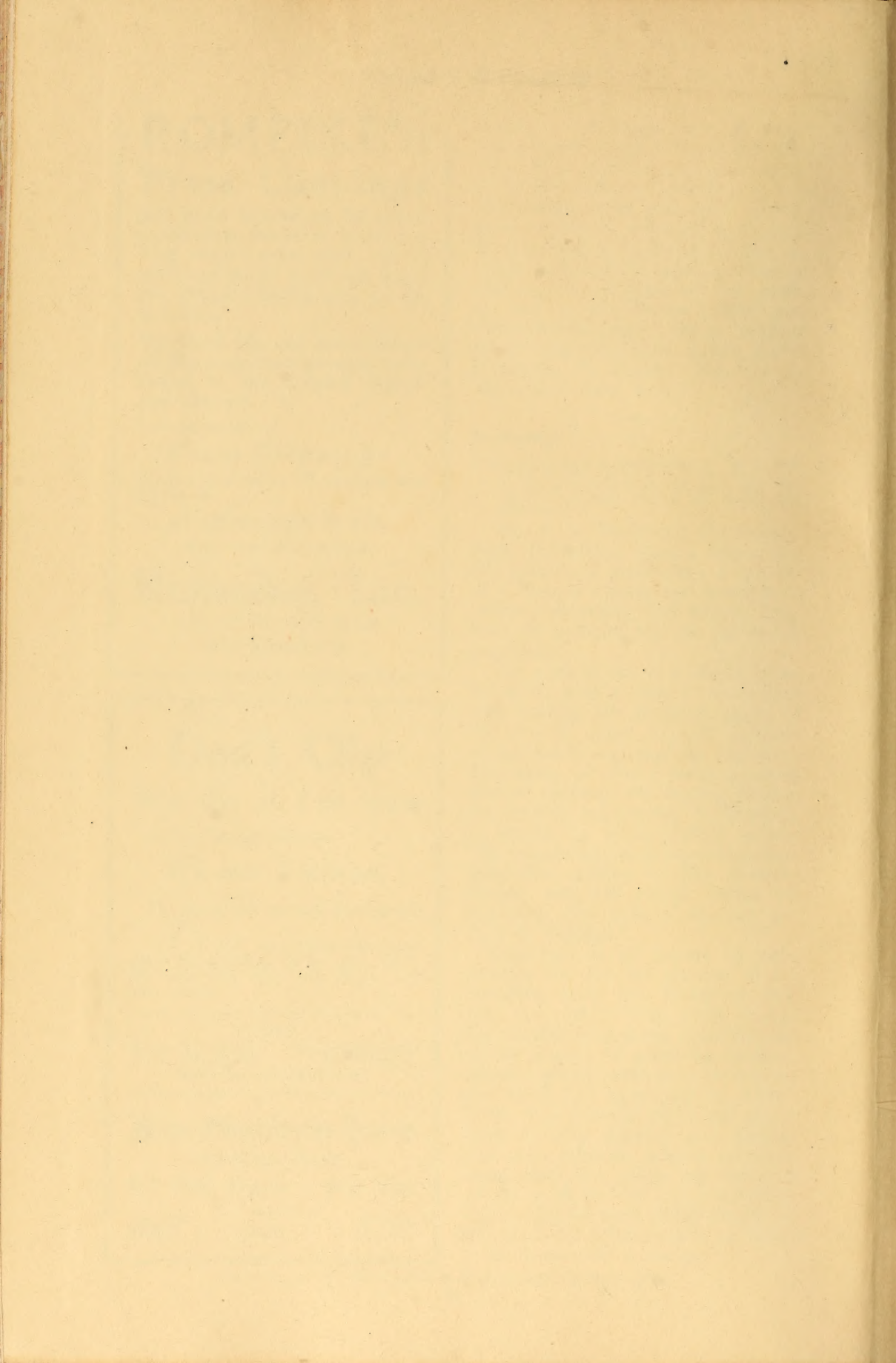
Household Plumbing and Sanitation. By J. Pickering Putnam, B.A., F. I. A. I. Size, 5 1/4 x 8; pages, over 700; illustrations, many. Net, \$3.75. Doubleday, Page & Co., Garden City, New York.

This is an illustrated and exceedingly interesting volume embodying the results of more than a quarter of a century's study and research in sanitary plumbing, and written from both the practical and the theoretical standpoint.

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